2335

Rainfall and Runoff Quantity and Quality Characteristics of Four Urban Land-Use Catchments in Fresno, California, October 1981 to April 1983

United States
Geological
Survey
Water-Supply
Paper 2335

Prepared in cooperation
with the Fresno Metropolitan
Flood Control District

U.S. DEPARTMENT OF THE INTERIOR
March 3, 1849

READEX FICHE best copy available

I 19. 13:

AVAILABILITY OF BOOKS AND MAPS OF THE U.S. GEOLOGICAL SURVEY

Instructions on ordering publications of the U.S. Geological Survey, along with prices of the last offerings, are given in the current-year issues of the monthly catalog "New Publications of the U.S. Geological Survey." Prices of available U.S. Geological Survey publications released prior to the current year are listed in the most recent annual "Price and Availability List." Publications that are listed in various U.S. Geological Survey catalogs (**see back inside cover**) but not listed in the most recent annual "Price and Availability List" are no longer available.

Prices of reports released to the open files are given in the listing "U.S. Geological Survey Open-File Reports," updated monthly, which is for sale in microfiche from the U.S. Geological Survey, Books and Open-File Reports Section, Federal Center, Box 25425, Denver, CO 80225. Reports released through the NTIS may be obtained by writing to the National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161; please include NTIS report number with inquiry.

Order U.S. Geological Survey publications **by mail** or **over the counter** from the offices given below.

BY MAIL

Books

Professional Papers, Bulletins, Water-Supply Papers, Techniques of Water-Resources Investigations, Circulars, publications of general interest (such as leaflets, pamphlets, booklets), single copies of Earthquakes & Volcanoes, Preliminary Determination of Epicenters, and some miscellaneous reports, including some of the foregoing series that have gone out of print at the Superintendent of Documents, are obtainable by mail from

U.S. Geological Survey, Books and Open-File Reports
Federal Center, Box 25425
Denver, CO 80225

Subscriptions to periodicals (Earthquakes & Volcanoes and Preliminary Determination of Epicenters) can be obtained ONLY from the

Superintendent of Documents
Government Printing Office
Washington, D.C. 20402

(Check or money order must be payable to Superintendent of Documents.)

Maps

For maps, address mail orders to

U.S. Geological Survey, Map Distribution
Federal Center, Box 25286
Denver, CO 80225

Residents of Alaska may order maps from

Alaska Distribution Section, U.S. Geological Survey,
New Federal Building - Box 12
101 Twelfth Ave., Fairbanks, AK 99701

OVER THE COUNTER

Books

Books of the U.S. Geological Survey are available over the counter at the following Geological Survey Public Inquiries Offices, all of which are authorized agents of the Superintendent of Documents:

- **WASHINGTON, D.C.**--Main Interior Bldg., 2600 corridor, 18th and C Sts., NW.
- **DENVER, Colorado**--Federal Bldg., Rm. 169, 1961 Stout St.
- **LOS ANGELES, California**--Federal Bldg., Rm. 7638, 300 N. Los Angeles St.
- **MENLO PARK, California**--Bldg. 3 (Stop 533), Rm. 3128, 345 Middlefield Rd.
- **RESTON, Virginia**--503 National Center, Rm. 1C402, 12201 Sunrise Valley Dr.
- **SALT LAKE CITY, Utah**--Federal Bldg., Rm. 8105, 125 South State St.
- **SAN FRANCISCO, California**--Customhouse, Rm. 504, 555 Battery St.
- **SPOKANE, Washington**--U.S. Courthouse, Rm. 678, West 920 Riverside Ave..
- **ANCHORAGE, Alaska**--Rm. 101, 4230 University Dr.
- **ANCHORAGE, Alaska**--Federal Bldg, Rm. E-146, 701 C St.

Maps

Maps may be purchased over the counter at the U.S. Geological Survey offices where books are sold (all addresses in above list) and at the following Geological Survey offices:

- **ROLLA, Missouri**--1400 Independence Rd.
- **DENVER, Colorado**--Map Distribution, Bldg. 810, Federal Center
- **FAIRBANKS, Alaska**--New Federal Bldg., 101 Twelfth Ave.

Rainfall and Runoff Quantity and Quality Characteristics of Four Urban Land-Use Catchments in Fresno, California, October 1981 to April 1983

By RICHARD N. OLTMANN and MICHAEL V. SHULTERS

Prepared in cooperation with the
Fresno Metropolitan Flood Control District

U.S. GEOLOGICAL SURVEY WATER-SUPPLY PAPER 2335

DEPARTMENT OF THE INTERIOR
MANUEL LUJAN, Jr., Secretary

U.S. GEOLOGICAL SURVEY
Dallas L. Peck, Director

March 3, 1849

Any use of trade, product, or firm names
in this publication is for descriptive purposes only
and does not imply endorsement by the U.S. Government

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1989

For sale by the
Books and Open-File Reports Section
U.S. Geological Survey
Federal Center, Box 25425
Denver, CO 80225

Library of Congress Cataloging-in-Publication Data

Oltmann, R.N. (Richard N.)
Rainfall and runoff quantity and quality characteristics of four urban land-use catchments in Fresno, California, October 1981 to April 1983 / by Richard N. Oltmann and Mitchael V. Shulters : prepared in cooperation with the Fresno Metropolitan Flood Control District.
p. cm.—(U.S. Geological Survey water-supply paper ; 2335)
Bibliography: p.
Supt. of Docs. no.: I 19.13:2335
1. Water quality management—California—Fresno Region. 2. Watershed management—California—Fresno Region. 3. Rain and rainfall—California—Fresno Region. 4. Runoff—California—Fresno Region. 5. Pesticides—Environmental aspects—California—Fresno Region. I. Shulters, M.V., 1950– . II. Fresno Metropolitan Flood Control District. III. Title. IV. Series: Water-supply paper (Washington, D.C.) ; 2335.
TC801.U2 no. 2335
[TD225.F85]
553.7'0973 s—dc19 89-600020
[363.7'394'0979482] CIP

CONTENTS

Abstract 1
Introduction 1
    Background 1
    Objectives and scope 2
Description of study area 2
Site selection and description 2
Data types and data collection 2
Description of hydrologic conditions during data collection period 4
Data analysis 5
    Rainfall and runoff quantity data 5
        1981-83 storm characteristics 5
        Rainfall-runoff regression analysis 9
        Rainfall-runoff response 13
    Rainfall quality samples 13
        Comparison of rainfall quality 13
        Computation of rainfall constituent loads 14
    Runoff quality samples 16
        Comparison of catchment runoff quality using discrete sample data 16
        Variation of constituent concentrations throughout a storm 19
        Regression analysis of constituent concentrations 25
        Computation of runoff constituent loads 26
        Characterization and regression analysis of constituent event mean concentrations 27
        Estimation of land-use mean annual constituent unit loads 31
        Dry-weather runoff samples 31
    Atmospheric dry-deposition quality samples 32
    Street-surface particulate quality samples 32
    Comparison of rainfall and runoff quality data 33
    Pesticides 35
Comparison with water-quality criteria and standards 37
Summary 38
Selected References 45

FIGURES

1. Index map of California showing Fresno study area 3
2. Photograph of multiple-use stormwater retention basin with inundated baseball diamond 4
3. Map showing location of catchments and rainfall and runoff monitoring sites 5
4. Maps showing monitored catchments 6
5. Graphs showing daily rainfall and storms for which rainfall or runoff quality data were collected 10
6. Graphs showing results of rainfall-runoff regression analysis for each of four monitored catchments 11
7. Flow hydrographs and hyetographs for each of four monitored catchments for a typical storm (November 17, 1981) 14

8. Schematic plots of four rainfall constituents that were determined to be significantly different **15**
9. Schematic plots showing comparison between catchments for selected constituents using runoff quality data **17**
10. Pie diagrams of average concentrations of dissolved major ions for runoff for each of the four monitored catchments **20**
11. Typical constituent concentration plots and flow hydrographs for two residential and commercial catchments **21**
12. Typical constituent concentration plots and flow hydrographs for industrial catchments **24**
13. Graph showing relation of dissolved ammonia plus organic nitrogen and specific conductance using discrete runoff data for multiple-dwelling residential catchment **25**
14–16. Graphs showing results of constituent concentration and specific conductance regression analysis for the:
    14. Single-dwelling residential catchment **26**
    15. Multiple-dwelling residential catchment **27**
    16. Commercial catchment **28**
17. Graph showing computation of runoff load using LOADS program **29**
18–20. Graphs showing comparison of constituent event mean concentrations and:
    18. Number of days since first storm of rain season **29**
    19. Number of dry hours since last storm **30**
    20. Runoff volume **30**
21. Graph showing comparison of total recoverable lead for atmospheric dry deposition and total dry-deposition material rate with time for the industrial and single-dwelling residential sites **33**
22. Graph showing comparison of constituent atmospheric dry-deposition concentrations with time for the industrial and single-dwelling residential sites **34**
23. Pie diagram of average concentrations of dissolved major ions for rainfall for all monitored rainfall sites **35**
24. Chronological bar chart of diazinon and parathion concentrations in storm-composite rainfall samples collected at industrial and single-dwelling residential sites **36**
25. Time-series plot showing parathion concentration, parathion loading, and storm rainfall totals at the single-dwelling residential site **37**
26-28. Chronological bar charts of:
    26. Malathion concentrations in storm composite rainfall samples collected at industrial and single-dwelling residential sites **37**
    27. Organochlorine insecticide concentrations in storm-composite rainfall samples collected at industrial and single-dwelling residential sites **38**
    28. 2,4-D concentrations in storm-composite rainfall samples collected at industrial and single-dwelling residential sites **38**
29. Schematic plots showing comparison of runoff quality data and criteria values for constituents that have primary drinking water standards **39**
30. Schematic plots showing comparison of runoff quality data and criteria values for constituents that have secondary drinking water standards **42**

TABLES

1. Characteristics of the four monitored urban runoff catchments **48**
2. Quality constituents analyzed for in rainfall, runoff, atmospheric dry-deposition, and street-surface particulate samples **49**
3. Average monthly rainfall totals for Fresno, California, compared to study period monthly rainfall totals **51**

4. Storm characteristics for storms monitored at four catchments **52**
5. Statistical summary of storm characteristics for storms monitored at four catchments **57**
6. Statistical summary of rainfall quality data: industrial site **58**
7. Statistical summary of rainfall quality data: single-dwelling residential site **59**
8. Statistical summary of rainfall quality data: laboratory site **61**
9. Results of statistical comparison testing between sites for composite rainfall quality samples **63**
10. Rainfall constituent event mean concentrations and loads for storms monitored at industrial site **64**
11. Rainfall constituent event mean concentrations and loads for storms monitored at single-dwelling residential site **65**
12. Statistical summary of discrete runoff sample data: industrial catchment **67**
13. Statistical summary of discrete runoff sample data: single-dwelling residential catchment **69**
14. Statistical summary of discrete runoff sample data: multiple-dwelling residential catchment **71**
15. Statistical summary of discrete runoff sample data: commercial catchment **73**
16. Results of statistical comparison testing between catchments using discrete runoff quality data **75**
17. Results of linear regression analysis using discrete runoff sample data **76**
18. Constituent storm runoff loads: industrial catchment **77**
19. Constituent storm runoff loads: single-dwelling residential catchment **80**
20. Constituent storm runoff loads: multiple-dwelling residential catchment **84**
21. Constituent storm runoff loads: commercial catchment **89**
22. Significant variables affecting constituent event mean concentrations **94**
23. Results of linear regression analysis using runoff event mean concentration data **95**
24. Statistical summary of runoff event mean concentration data for all monitored catchments **96**
25. Estimated average annual constituent unit loads for each land-use type **99**
26. Statistical summary of atmospheric dry-deposition quality data: industrial site **100**
27. Statistical summary of atmospheric dry-deposition quality data: single-dwelling residential site **101**
28. Statistical summary of street-surface particulate quality samples: industrial catchment **103**
29. Statistical summary of street-surface particulate quality samples: single-dwelling residential catchment **104**
30. Statistical summary of street-surface particulate quality samples: multiple-dwelling residential catchment **105**
31. Statistical summary of street-surface particulate quality samples: commercial catchment **107**
32. Percentage of runoff load attributable to rainfall load for the industrial and two residential catchments **109**
33. Summary of pesticides detected in rainfall, runoff, atmospheric dry-deposition, and street-surface particulate samples **112**
34. Statistical summary of pesticides detected in rainfall samples **113**
35. Statistical summary of most frequently detected pesticides in runoff for each catchment **114**

METRIC CONVERSION FACTORS

In this report some measurements are given in inch-pound units and some laboratory data are reported in metric units. Conversion factors from inch-pound units to International System of Units (SI) are given below.

Multiply	By	To obtain
acres	0.4047	hm^2 (square hectometers)
ft (feet)	0.3048	m (meters)
ft/mi (feet per mile)	0.18948	m/km (meters per kilometer)
ft^3/s (cubic feet per second)	0.0283	m^3/s (cubic meters per second)
inches	25.4	mm (millimeters)
mi (miles)	1.609	km (kilometers)
mi^2 (square miles)	2.590	km^2 (square kilometers)
lb (pounds)	0.4536	kg (kilograms)
lb/acre (pounds per acre)	1.1208	kg/hm^2 (kilograms per square hectometer)

Other Abbreviations Used

meq/L	milliequivalents per liter
mg/L	milligrams per liter
μg/d	micrograms per day
μg/L	micrograms per liter
μS/cm at 25 °C	microsiemens per centimeter at 25 degrees Celsius

Rainfall and Runoff Quantity and Quality Characteristics of Four Urban Land-Use Catchments in Fresno, California, October 1981 to April 1983

By Richard N. Oltmann *and* Michael V. Shulters

Abstract

Rainfall and runoff quantity and quality were monitored for industrial, single-dwelling residential, multiple-dwelling residential, and commercial land-use catchments during the 1981–82 and 1982–83 rain seasons. Storm-composite rainfall and discrete runoff samples were analyzed for numerous inorganic, biological, physical, and organic constituents. Atmospheric dry-deposition and street-surface particulate samples also were collected and analyzed.

With the exception of the industrial catchment, the highest runoff concentrations for most constituents occurred during the initial storm runoff and then decreased throughout the remainder of the storm, independent of hydraulic conditions. Metal concentrations were high during initial runoff, but also increased as flow increased. Constituent concentrations for the industrial catchment fluctuated greatly during storms.

Statistical tests showed higher ammonia plus organic nitrogen, ammonia, pH, and phenol concentrations in rainfall at the industrial site than at the single-dwelling residential and laboratory sites. Statistical testing of runoff quality data showed higher concentrations for the industrial catchment than for the two residential and commercial catchments for most constituents. Total recoverable lead was one of the few constituents that had lower concentrations for the industrial catchment than for the other three catchments. The two residential catchments showed no significant difference in runoff concentrations for 50 of the 57 constituents used in the statistical analysis. The commercial catchment runoff concentrations for most constituents generally were similar to the residential catchments.

Although constituent concentrations generally were higher for the industrial catchment than for the commercial catchment, constituent storm loads from the commercial catchment were similar to the industrial catchment because of the greater runoff volume from the highly impervious commercial catchment. Between 10 and 50 percent of the constituent runoff loads for the two residential catchments were attributed to the rainfall load, with the percentages generally considerably less for the industrial catchment.

Event mean concentrations (EMC) for most constituents for all but the industrial catchment were highest for the first two or three storms of the rain season after which they became almost constant. Constituent event mean concentrations for the industrial catchment generally did not show any pattern throughout a rain season. Multiple-regression predictor equations for event mean concentrations were developed for several constituents for all sites. Average annual constituent unit loads were computed for 18 constituents for each catchment.

The organophosphorus compounds, diazinon, malathion, and parathion were the most prevalent pesticides detected in rainfall. Diazinon was detected in all 54 rainfall samples. Parathion and malathion were detected in 49 and 50 samples, respectively. Other pesticides detected in rainfall included chlordane, lindane, methoxychlor, endosulfan, and 2,4-D. Of these, only methoxychlor and endosulfan were not consistently detected in runoff.

INTRODUCTION

Background

Fresno Metropolitan Flood Control District (FMFCD) has routed urban stormwater runoff to local manmade retention basins since 1956. The stormwater runoff is allowed to percolate through the underlying soils, thereby (1) disposing of the excess stormwater runoff, and (2) recharging the aquifer which underlies the city of Fresno and is the city's domestic water source.

Public Law 92-500 (the Clean Water Act) and Public Law 93-523 (the Safe Drinking Water Act) set forth national priorities concerning the identification and control of constituents discharged into waters of the United States, and for ensuring the preservation of the Nation's drinking water supplies. Section 208 of Public Law 92-500 identifies urban stormwater runoff as a potential source of pollutants. Section 1421 of Public Law 93-523 decreed the U.S. Environmental Protection Agency (EPA) to establish regulations to control underground injections to protect drinking water sources.

The U.S. Environmental Protection Agency initiated the National Urban Runoff Program (NURP) in order to obtain adequate data to assess urban stormwater effects and to evaluate and develop effective management and control practices. NURP consists of 28 individual urban runoff studies across the country characterizing urban runoff, determining constituent loads, and evaluating effects and control practices. The FMFCD applied for and received a NURP grant from

EPA through the California State Water Resources Control Board to investigate the potential environmental effects associated with the recharge of urban stormwater runoff in manmade basins. The aquifer that underlies Fresno and receives the urban runoff has been designated by the EPA as a "sole source" aquifer. Only 1 of the other 28 studies investigated ground water as an urban runoff receiving water.

The objectives of the Fresno NURP are to:

1. Determine the character of urban stormwater runoff from different land-use areas, identifying nonpoint sources and concentrations of the constituents.
2. Determine the effects of the retention and recharge of urban storm runoff and its related constituents on the receiving ground water and soils.
3. Identify management practices which insure the safe, controlled disposal of urban storm runoff in retention/recharge basins.

The FMFCD requested the U.S. Geological Survey to complete objective 1. Objective 2 is to be completed by the Agricultural Research Service, U.S. Department of Agriculture, and objective 3 is to be completed by Brown and Caldwell Consulting Engineers.

Objectives and Scope

The objectives of the Geological Survey's study and this report are to:

1. Determine the rate of runoff for the following land uses: industrial, single-dwelling residential, multiple-dwelling residential, and commercial.
2. Identify the type and volume of constituents transported by the runoff water from the four different selected land-use types.
3. Determine the concentrations of nonpoint source constituents (rainfall, atmospheric dry deposition, street-surface particulate) transported by the runoff water.
4. Determine the time relations between runoff quantity and quality.

The scope of the study included monitoring the quantity, quality, and rate of rainfall and stormwater runoff from four selected land-use catchments during the 1981–82 and 1982–83 rain seasons (October to April). Rainfall and runoff samples were analyzed for inorganic, biological, physical, and organic constituents. Atmospheric dry-deposition and street-surface particulate samples also were collected and analyzed for inorganic, physical, and organic constituents. Of the 28 NURP studies, the Fresno study is one of the few that investigated urban runoff associated with a particular land use; it also includes one of only two industrial catchments investigated under the NURP.

DESCRIPTION OF STUDY AREA

The city of Fresno is located about 160 miles southeast of San Francisco, California (fig. 1), within the predominantly agricultural San Joaquin Valley. The valley is bounded by the Coast Ranges on the west and the Sierra Nevada on the east. Fresno is subject to winter storms that move onshore from the Pacific Ocean, over the Coast Ranges, and into the valley. The average annual rainfall for the study area is about 10 inches, nearly all of which falls during October to April.

The topography of the study area is virtually flat with an average gradient of about 8 ft/mi. Because of the flat terrain and lack of adequate water courses through the city, manmade stormwater retention basins have been constructed. The basins average 10 to 15 acres in size, each servicing about 1 mi^2 of urbanized area. Most of the basins are designed for multiple use, such as parks, athletic fields (fig. 2), and groundwater recharge facilities, during the nonrain season.

The city of Fresno occupies about 150 mi^2, of which about 27 percent is residential; 4 percent, commercial; and 6 percent, industrial land use (City of Fresno, written commun., April 1978). The remaining land uses consist of agricultural, transportation, public facilities, and vacant land. The city is surrounded by agricultural land with the primary crops consisting of grapes, figs, cotton, alfalfa, peaches, and almonds. Heavy industrial areas do not exist in Fresno, and there is not a predominant industry.

SITE SELECTION AND DESCRIPTION

Catchments were selected for runoff monitoring for industrial, single-dwelling residential, multiple-dwelling residential, and commercial land-use areas using the following criteria:

1. Catchment land use had to be about 80- to 90-percent homogeneous.
2. Catchment had to be 80-percent developed to avoid substantial construction activity during the period of data collection.
3. Catchment had to have a suitable site for an equipment shelter and storm-drain access.

All the selected catchments met the above criteria except the industrial catchment. Of the very few industrial catchments from which to choose, a catchment could not be found that met the 80-percent developed criteria. As shown in table 1, which is a summary of catchment characteristics, the selected catchment was only 65.8-percent developed.

The locations of the four catchments that were monitored throughout the study period are shown in figures 3 and 4.

DATA TYPES AND DATA COLLECTION

Four data types collected throughout the two rain seasons were:

1. Rainfall rate and quality,
2. Runoff rate and quality,
3. Atmospheric dry-deposition quality, and
4. Street-surface particulate quality.

As part of the data collection for runoff rate and quality, dry-weather runoff samples were collected during the summer months at the two residential sites. Rainfall, runoff, dry-deposition, street-surface particulate, and dry-weather runoff quality samples were analyzed for inorganic, biological, physical, and organic constituents as shown in table 2.

All quality samples were analyzed at the U.S. Geological Survey Central Laboratory in Arvada, Colorado, except for biochemical oxygen demand, fecal coliform bacteria,

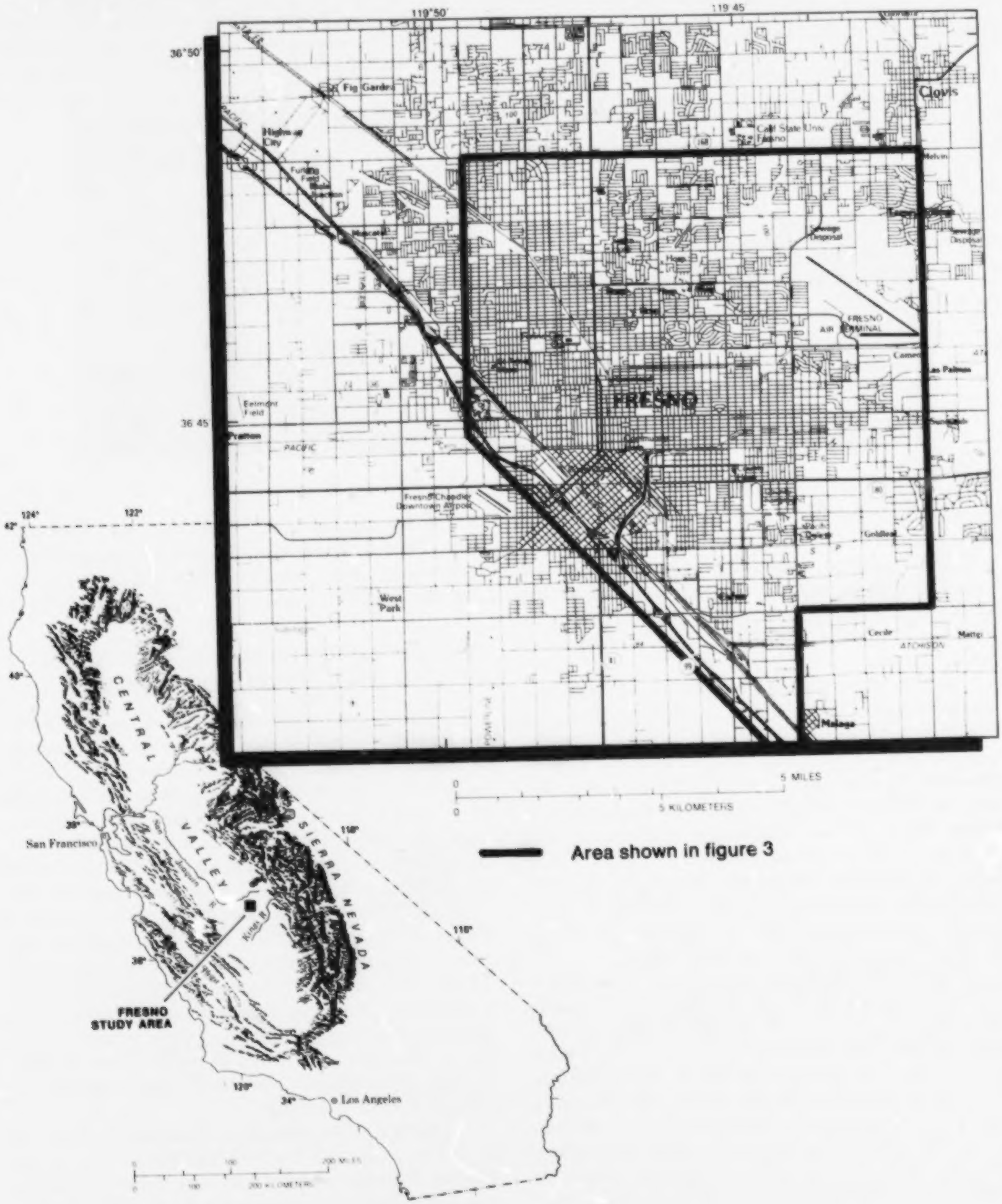

119°50'
119°45'
36°50'
36°45'
Fig Garden
Highway City
Clovis
Calif State Univ Fresno
Melvin
FRESNO AIR TERMINAL
Las Palmas
FRESNO
Belmont Field
PACIFIC
Fresno Chandler Downtown Airport
West Park
Malaga
ATCHISON
0
5 MILES
0
5 KILOMETERS
Area shown in figure 3
124°
122°
42°
40°
38°
36°
34°
120°
118°
116°
CENTRAL
VALLEY
SIERRA
NEVADA
San Francisco
Los Angeles
FRESNO STUDY AREA
Kings R
200 MILES
200 KILOMETERS

Figure 1. Index map of California showing Fresno study area.

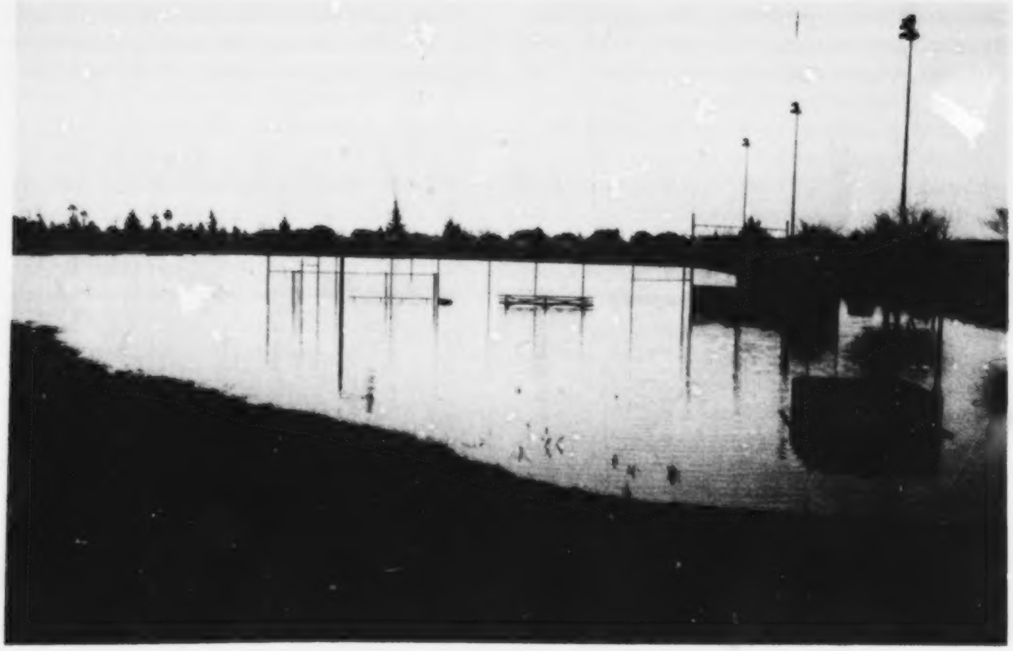


Figure 2. Multiple-use stormwater retention basin with inundated baseball diamond.

suspended sediment, and particle-size analyses. Biochemical oxygen demand samples were analyzed by BSK & Associates of Fresno, California; fecal coliform bacteria were analyzed by project staff personnel at the project's Fresno laboratory; and sediment and particle-size analyses were performed by the U.S. Geological Survey Sediment Laboratory in Sacramento, California.

Rainfall quality samples were collected as a single bulk sample for an entire storm. Discrete runoff samples were collected throughout storms using automatic sampling equipment; however, organic samples were collected manually using glass containers. For some storms, several discrete samples per site were sent to the laboratory for analysis to provide data on the variation of constituent concentrations with time and flow, and to analyze relations of constituent concentration. For other storms, the automatic sampler was programmed to collect flow-weighted discrete samples (Oltmann and others, 1987) that were composited and sent to the laboratory for analysis for use in computing constituent storm loads.

Specific-conductance data were collected for all discrete runoff samples, including samples collected during storms that did not have samples sent to the laboratory for analysis. Most of the specific-conductance data for the storms that did not have laboratory data were used as input data to the relations of constituent concentrations and specific conductance, in order to estimate constituent concentration. The estimated constituent concentrations then were used to calculate constituent storm loads (refer to "Constituent Concentration Regression Analysis" and "Computation of Runoff Constituent Loads" sections). pH data were collected for most of the samples.

A discussion of the instrumentation used to collect the above listed data, the data collection and laboratory procedures used, and a listing of the data is given in Oltmann and others (1987).

DESCRIPTION OF HYDROLOGIC CONDITIONS DURING DATA COLLECTION PERIOD

According to the 104-year rainfall record collected by the National Weather Service, the average annual rainfall at the Fresno Air Terminal is 10.24 inches, of which 9.84 inches (96 percent) occur between September and April (table 3) (National Oceanic and Atmospheric Administration, 1981). The rainfall total during the first rain season of this study (1981–82) was near the average (110 percent of average); however, 44 percent of the rainfall total occurred in March (294 percent of monthly average). The second rain season of the study (1982–83) began about a month early with the occurrence of tropical storm Olivia on September 24–25, 1982. This was the start of a recordbreaking rain season that resulted in the September through April monthly rainfall totals exceeding monthly averages with the exception of December, which was 93 percent of the monthly average. The resulting rainfall total for this 8-month period was 239 percent of average.

During the first rain season, 56 storms occurred with 22 of these resulting in less than 0.10 inch of rain. The remaining 34 storms averaged 0.28 inch of rain. The second rain season had 67 storms through April 14, 1983 (monitoring equipment removal date), with 23 of these resulting in less than 0.10 inch of rain. The remaining 44 storms averaged 0.45 inch of rain, or 161 percent of the first rain season storms.

A plot of daily rainfall during the study period as measured by the National Weather Service at the Fresno Air Terminal is shown in figure 5. Also noted in the figure are storms for which rainfall and (or) runoff quality data were collected.

DATA ANALYSIS

Rainfall and Runoff Quantity Data

1981–83 Storm Characteristics

Storm characteristics were determined for all storms throughout the study period for each of the four monitored catchments that had complete rainfall and runoff records. The

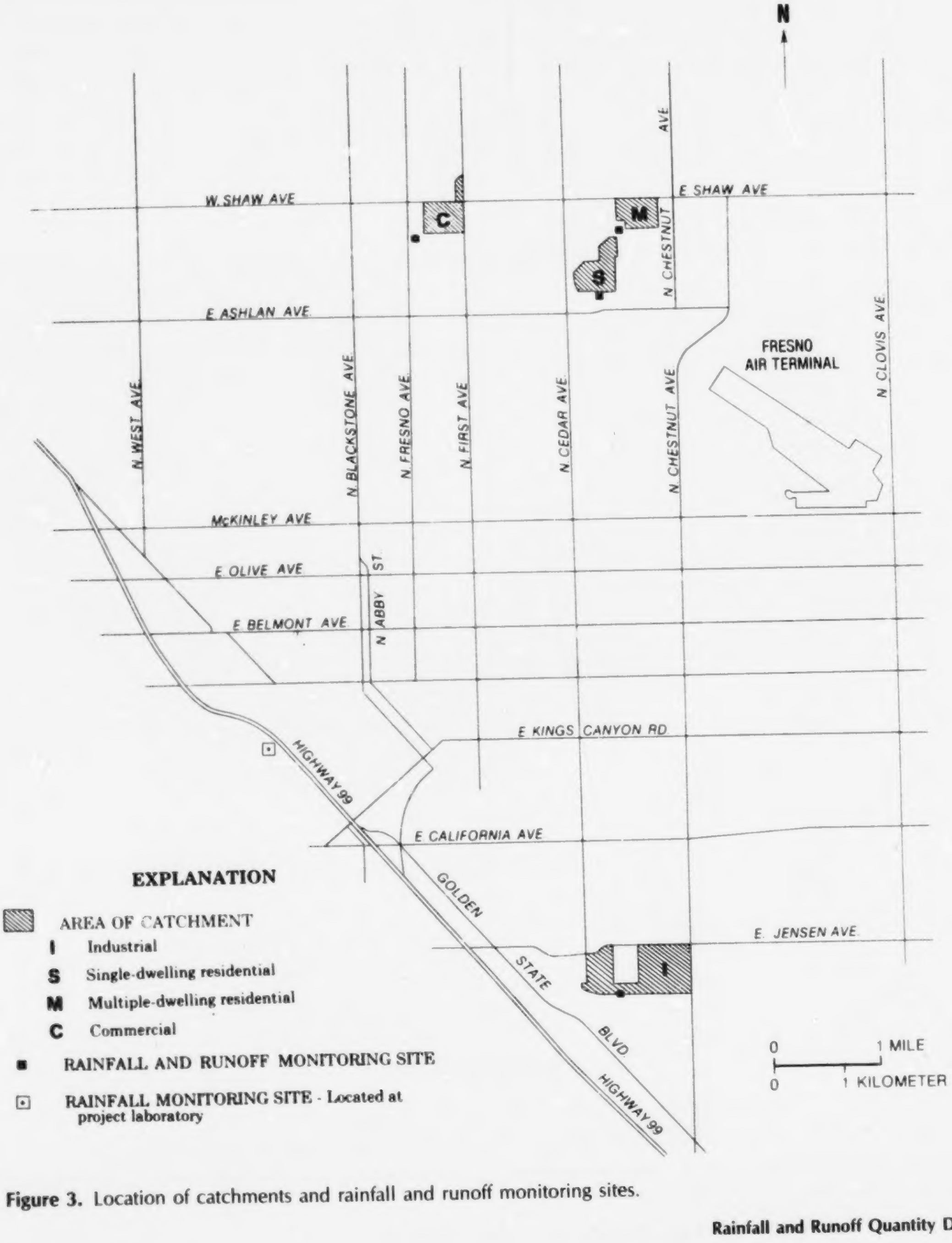

N
W. SHAW AVE
E SHAW AVE
E ASHLAN AVE
McKINLEY AVE
E OLIVE AVE
E BELMONT AVE
E KINGS CANYON RD
E CALIFORNIA AVE
E. JENSEN AVE
N WEST AVE
N BLACKSTONE AVE
N FRESNO AVE
N FIRST AVE
N CEDAR AVE
N CHESTNUT AVE
N CHESTNUT AVE
N ABBY ST
N CLOVIS AVE
FRESNO AIR TERMINAL
HIGHWAY 99
GOLDEN STATE BLVD.
HIGHWAY 99
C
M
S
I
0
1 MILE
0
1 KILOMETER
EXPLANATION
AREA OF CATCHMENT
I Industrial
S Single-dwelling residential
M Multiple-dwelling residential
C Commercial
RAINFALL AND RUNOFF MONITORING SITE
RAINFALL MONITORING SITE - Located at project laboratory

Figure 3. Location of catchments and rainfall and runoff monitoring sites.

storm characteristics include rainfall total, runoff volume, rainfall-runoff coefficient, maximum 20-minute rainfall total, peak flow, and rainfall and runoff duration. These storm characteristics and two additional variables, number of hours since the previous storm and the number of days since the first storm of the rain season, are listed in table 4.

Runoff volumes for each storm were computed using the runoff record and the RRLIST computer program documented by Doyle and Lorens (1982). The rainfall-runoff coefficient was determined by dividing the runoff volume (runoff depth) by the rainfall total (rainfall depth). Rainfall duration represents the time in minutes from the first recorded 0.01 inch of rainfall to the last 0.01 inch of rainfall for a storm. The storm-runoff duration represents the time in minutes that the storm-drain flow was about 0.01 ft^3/s (approximate flow-recording threshold) or greater. The number of hours since the previous storm represents the approximate time in hours between the last 0.01 inch of rainfall of the previous storm and the start of storm-drain flow (about 0.1 ft^3/s) for the following storm.

The rainfall-runoff coefficient should range between 0 and 1; however, some of the calculations for the multiple-dwelling residential and commercial catchments resulted in coefficients greater than 1. Coefficients greater than 1

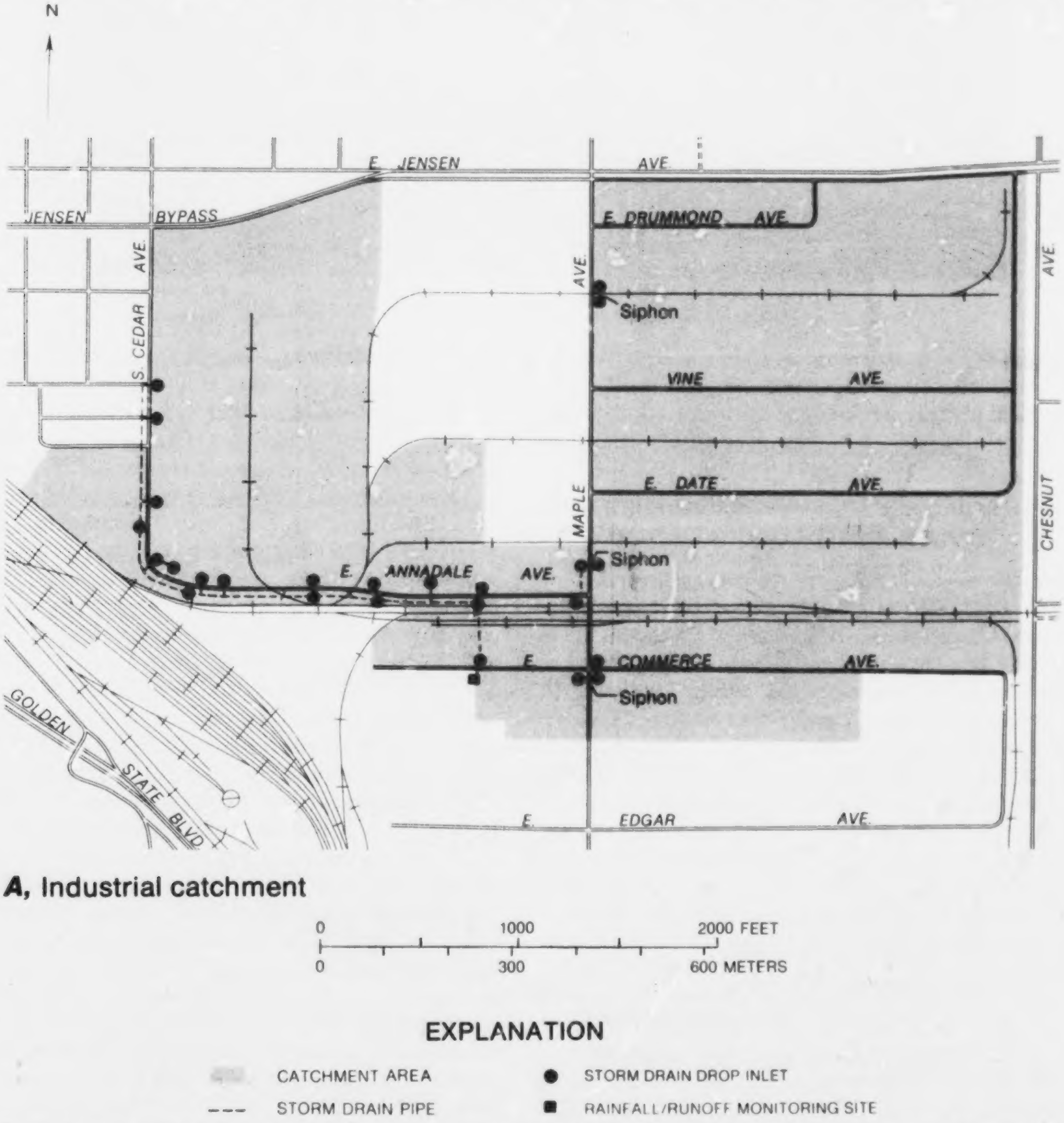
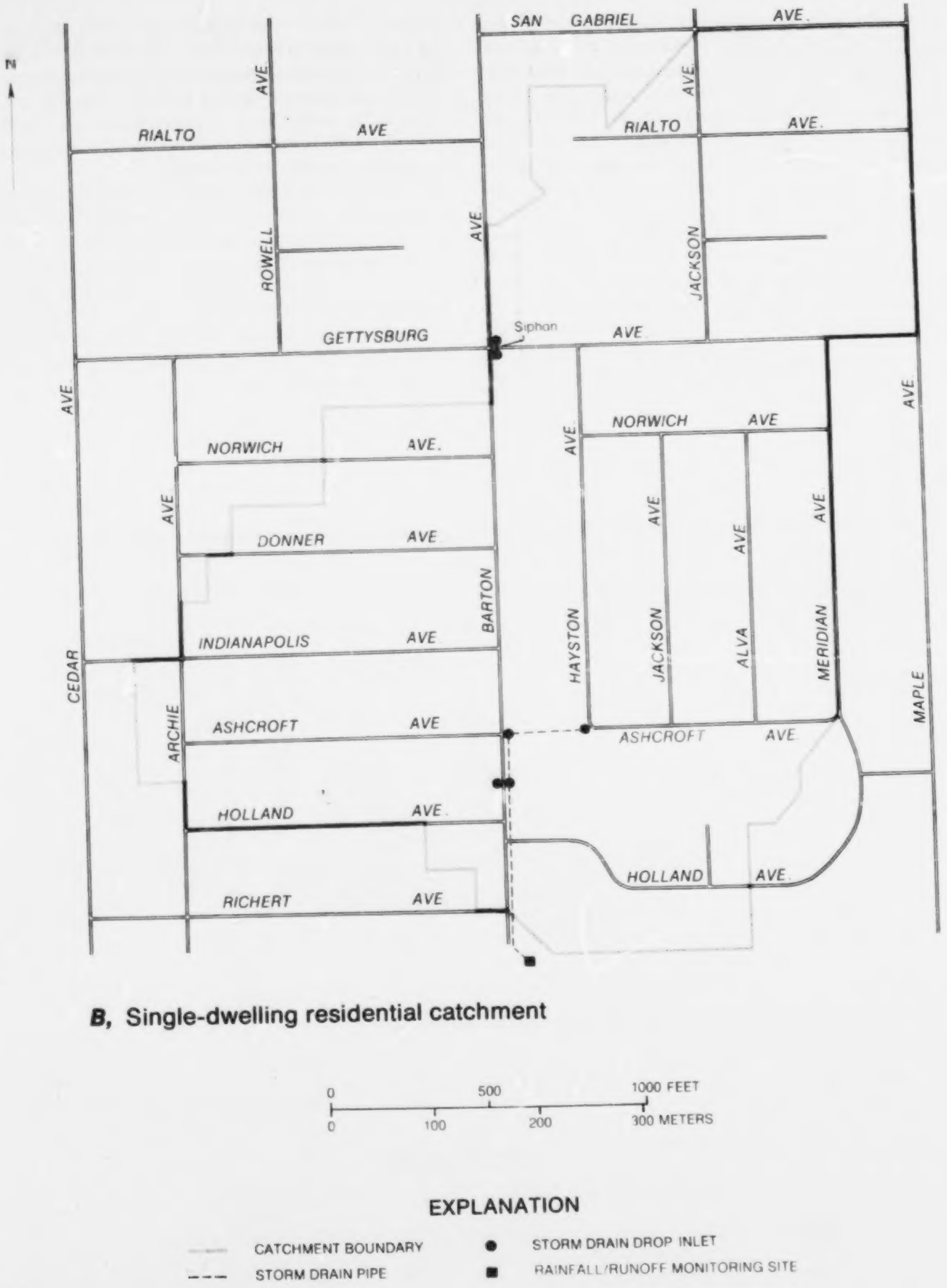

N
E. JENSEN AVE.
JENSEN BYPASS
S. CEDAR AVE.
E. DRUMMOND AVE.
MAPLE AVE.
Siphon
VINE AVE.
E. DATE AVE.
CHESNUT AVE.
E. ANNADALE AVE.
Siphon
E. COMMERCE AVE.
Siphon
E. EDGAR AVE.
GOLDEN STATE BLVD
A, Industrial catchment
0 1000 2000 FEET
0 300 600 METERS
EXPLANATION
CATCHMENT AREA
--- STORM DRAIN PIPE
● STORM DRAIN DROP INLET
■ RAINFALL/RUNOFF MONITORING SITE

Figure 4. Monitored catchments. *A*, Industrial catchment. *B*, Single-dwelling residential catchment. *C*, Multiple-dwelling residential catchment. *D*, Commercial catchment.


N
SAN GABRIEL AVE.
RIALTO AVE
RIALTO AVE.
ROWELL AVE
AVE
JACKSON AVE
GETTYSBURG AVE
Siphon
NORWICH AVE.
NORWICH AVE
DONNER AVE
INDIANAPOLIS AVE
ASHCROFT AVE
HOLLAND AVE.
HOLLAND AVE.
RICHERT AVE
CEDAR AVE.
ARCHIE AVE
BARTON AVE
HAYSTON AVE.
JACKSON AVE
ALVA AVE
MERIDIAN AVE
MAPLE AVE
0 500 1000 FEET
0 100 200 300 METERS
EXPLANATION
CATCHMENT BOUNDARY
STORM DRAIN PIPE
STORM DRAIN DROP INLET
RAINFALL/RUNOFF MONITORING SITE

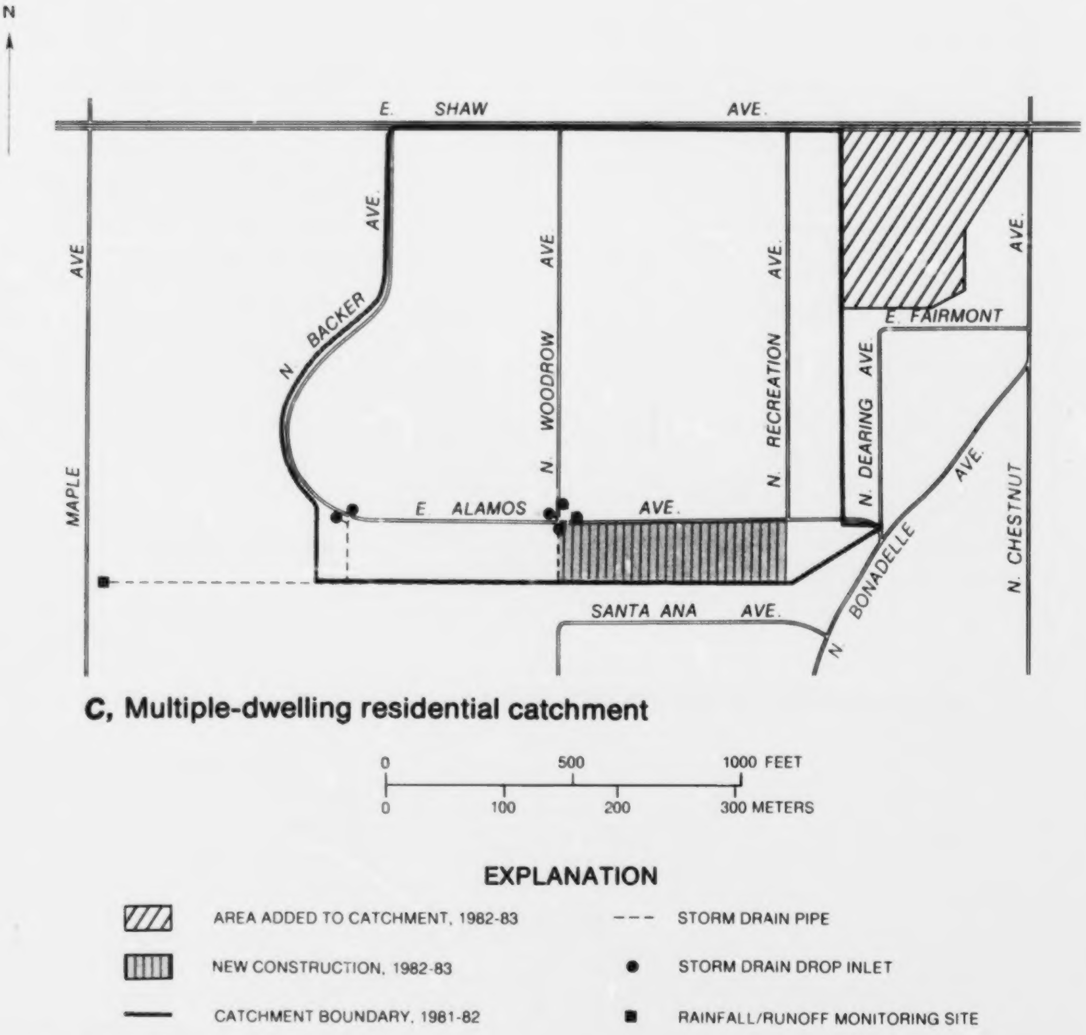
B, **Single-dwelling residential catchment**

Figure 4. Continued.

probably occur for the commercial catchment because of a combination of data collection inaccuracies and a 98.9-percent impervious catchment surface (table 1). Because of the high percentage of impervious surface, nearly all rainfall that lands on the catchment should drain off. Therefore, data collection inaccuracies become critical in this near-continuity situation. For example, if the recorded rainfall, which is collected at one location in or near the catchment, is less than the actual average rainfall over the catchment, a coefficient greater than 1 will result. Other data collection inaccuracies that could contribute to a coefficient greater than 1 include errors in collection of the storm-drain stage record, determination of stage discharge relation (Oltmann and others, 1987), and determination of the catchment drainage area.

Coefficients greater than 1 also were obtained for two storms for the multiple-dwelling residential site (1.01 on January 22 and 1.05 on February 28, 1983). Both storms were high rainfall intensity storms that caused the storm drain to flow full, therefore, the flow records were estimated for these periods (Oltmann and others, 1987). Another possible cause for the coefficients to be greater than 1 is that the high-intensity rainfall caused runoff from an adjacent catchment to enter the monitored catchment.

Table 5 represents a statistical summary of the storm characteristics data shown in table 4. Because of the unusually high rainfall total during the second rain season, the mean storm characteristics data shown in table 5 (except for the commercial catchment) probably are higher than the actual mean storm characteristics values. The effect of the high rainfall total on the mean rainfall-runoff coefficient is discussed in the section "Estimation of Land-Use Average Annual Constituent Unit Loads."

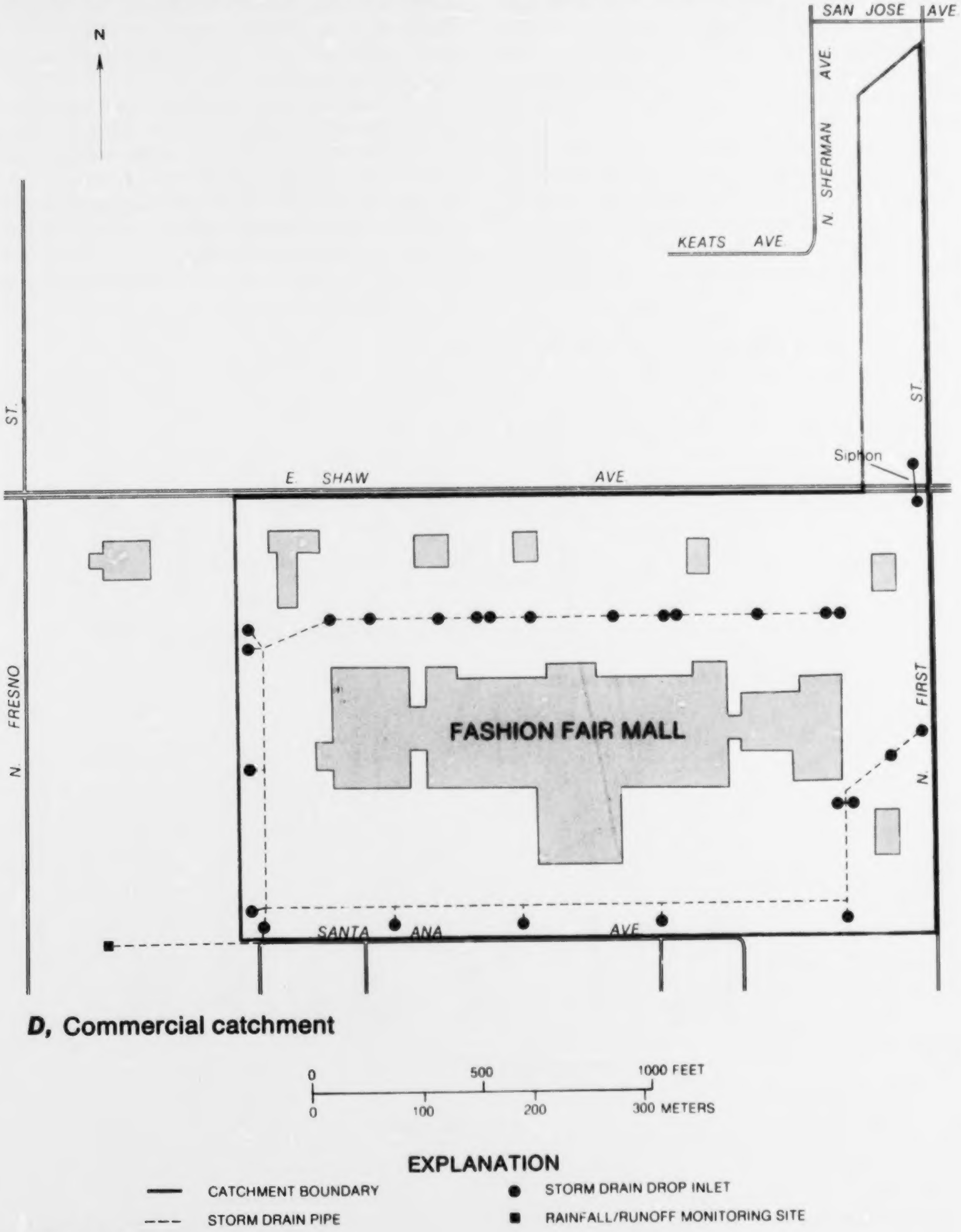

N
E. SHAW AVE.
MAPLE AVE.
N. BACKER AVE.
N. WOODROW AVE.
N. RECREATION AVE.
N. DEARING AVE.
E. FAIRMONT
N. CHESTNUT AVE.
E. ALAMOS AVE.
SANTA ANA AVE.
N. BONADELLE AVE.
0 500 1000 FEET
0 100 200 300 METERS
EXPLANATION
AREA ADDED TO CATCHMENT, 1982-83
NEW CONSTRUCTION, 1982-83
CATCHMENT BOUNDARY, 1981-82
STORM DRAIN PIPE
STORM DRAIN DROP INLET
RAINFALL/RUNOFF MONITORING SITE

C, Multiple-dwelling residential catchment

Figure 4. Continued.

Rainfall-Runoff Regression Analysis

Multiple linear-regression analysis for each of the four catchments was done using the data in table 4 and REG procedure of the computerized statistical analysis system, SAS (Helwig and Council, 1979). The dependent variable was designated as runoff and regressed against the independent variables rainfall total, maximum 20-minute rainfall total


N
SAN JOSE AVE
N. SHERMAN AVE.
KEATS AVE
N. FRESNO ST.
N. FIRST ST.
E. SHAW AVE
Siphon
FASHION FAIR MALL
SANTA ANA AVE
0
500
1000 FEET
0
100
200
300 METERS
EXPLANATION
CATCHMENT BOUNDARY
STORM DRAIN PIPE
STORM DRAIN DROP INLET
RAINFALL/RUNOFF MONITORING SITE

***D,* Commercial catchment**

Figure 4. Continued.

(MAX20), and number of hours since the previous storm (DRYHRS).

If DRYHRS is a significant independent variable, an appreciable part of the catchment surface has soil areas that need to reach saturation before runoff occurs from these areas, and (or) significant depression areas must be filled before runoff occurs. If MAX20 is a significant variable, the catchment soils have a high infiltration rate, and the rainfall rate must exceed the infiltration rate in order for runoff to occur from the pervious soil areas.

The regression results indicate that the significance of the three independent variables differed between catchments. Regression results for each of the four catchments are shown in figure 6, which includes the regression equation for estimating runoff volume, percent of variation of dependent variable explained by the independent variables adjusted for sample size (R^2), root mean square error, and a comparison plot of predicted and measured runoff.

The analysis for the commercial catchment produced a simple linear regression equation as the best model, with rainfall total being the only independent variable that was significant at the 0.05-significance level ($\alpha=0.05$). This result is again the direct result of the 98.9-percent impervious catchment surface.

The analysis for the other three catchments resulted in multiple logarithmic-linear regression equations. The only significant independent variables for the equations for the single-dwelling residential and industrial catchments were rainfall total and DRYHRS. All three independent variables were significant for the multiple-dwelling residential catchment. These results are consistent with the catchment characteristics data shown in table 1. All three catchments have a large

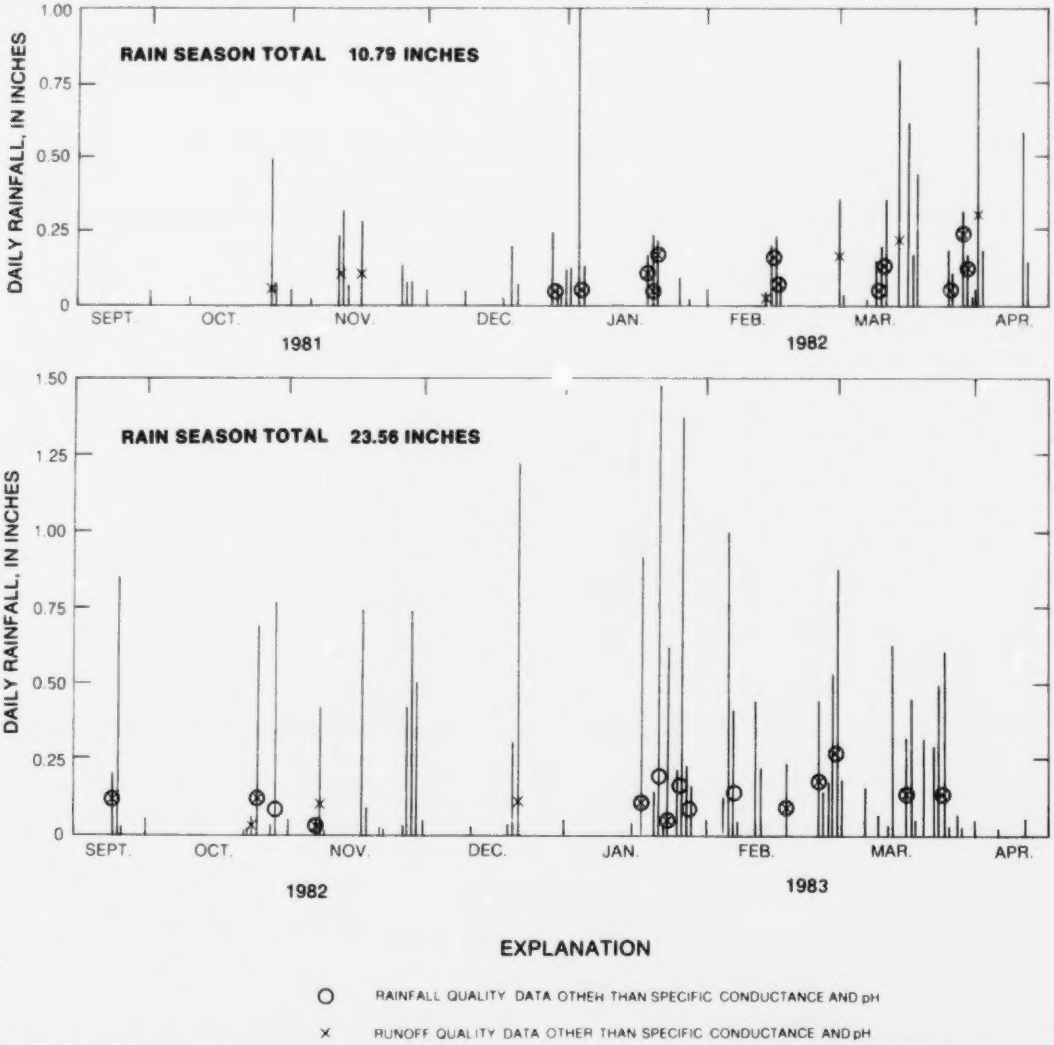


Figure 5. Daily rainfall and storms for which rainfall or runoff quality data were collected. (Daily rainfall totals measured at the Fresno Air Terminal by the National Weather Service.)

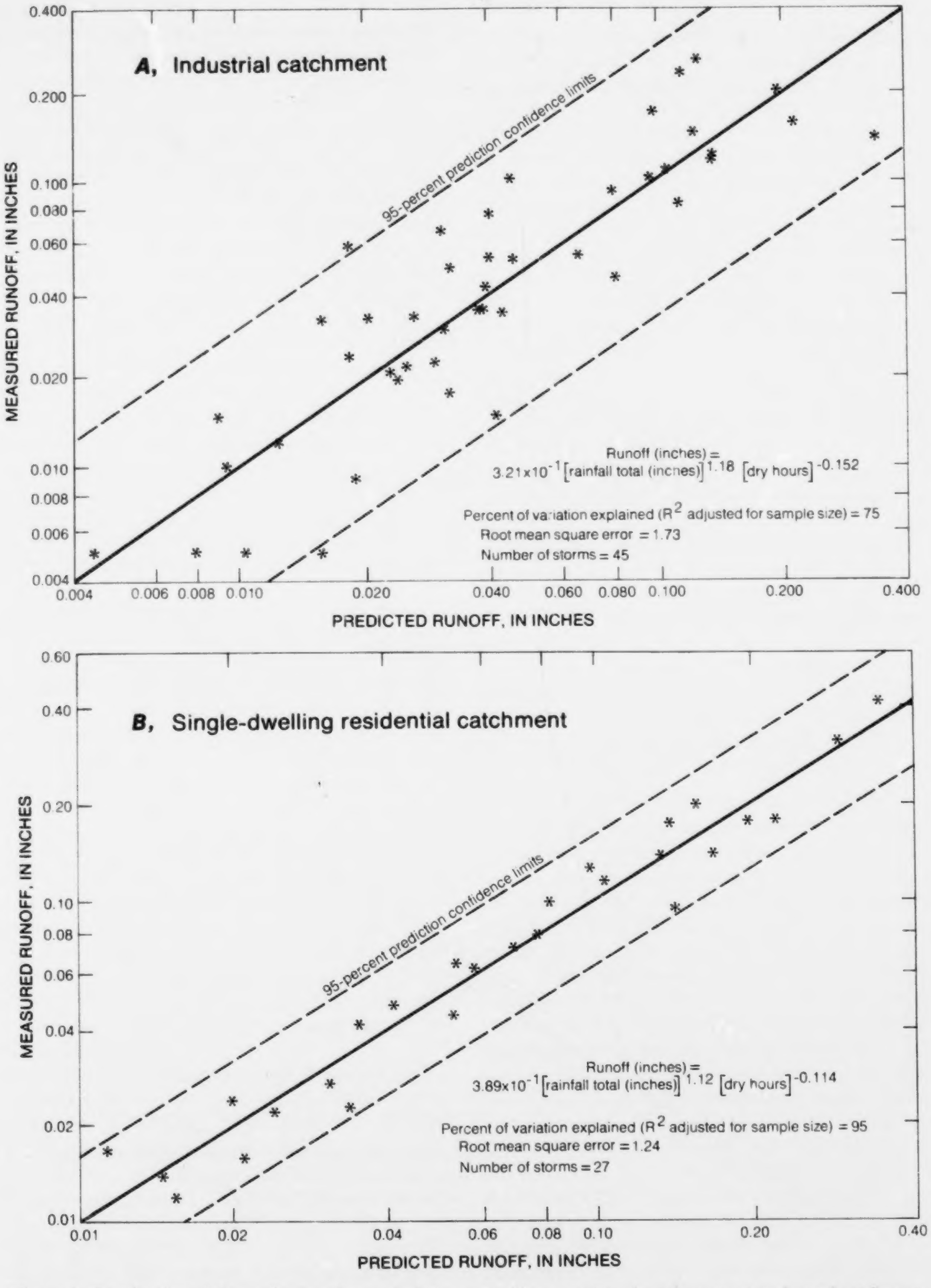


Figure 6. Results of rainfall-runoff regression analysis for each of four monitored catchments. *A*, Industrial catchment. *B*, Single-dwelling residential catchment. *C*, Multiple-dwelling residential catchment. *D*, Commercial catchment.

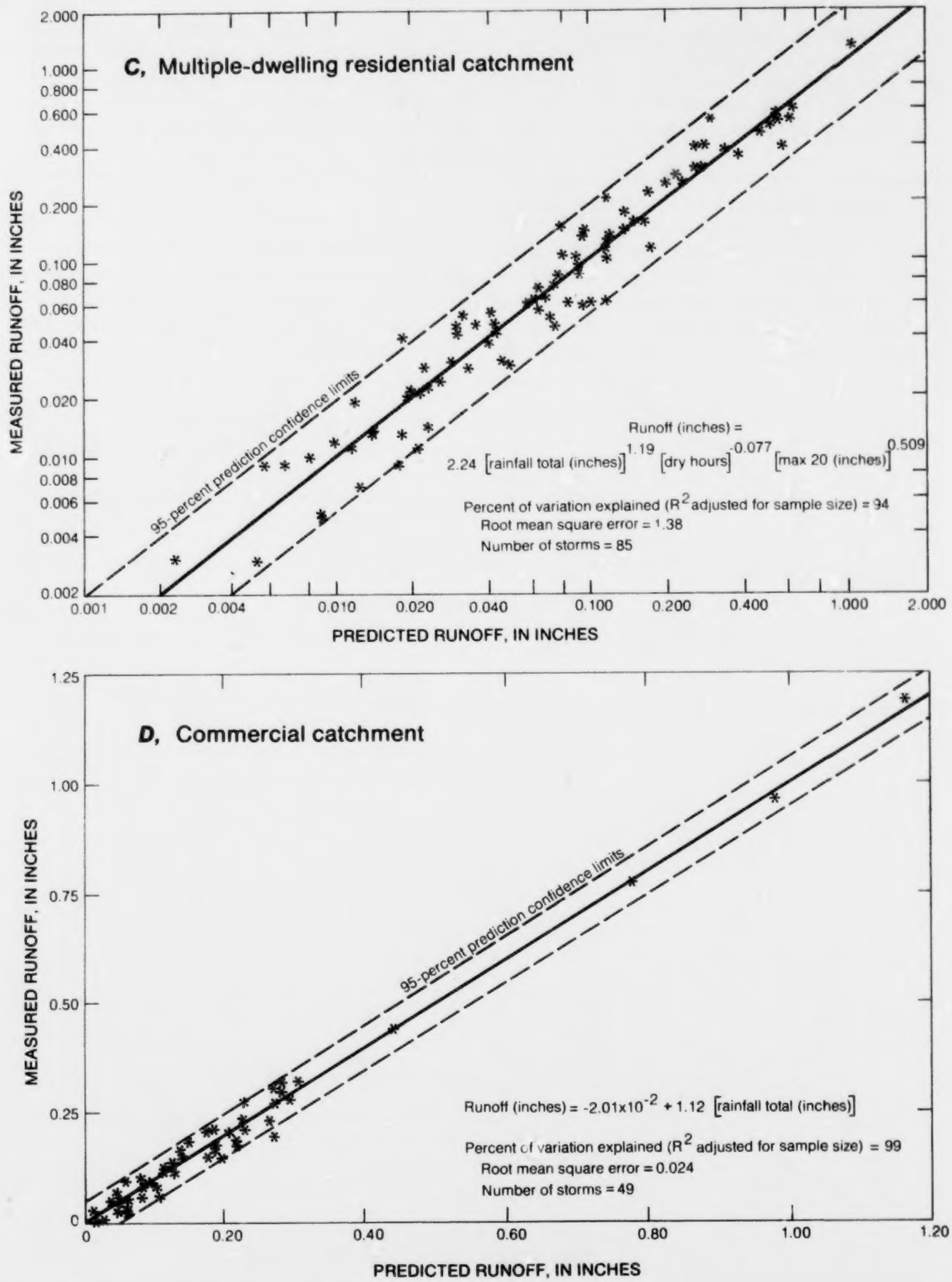


Figure 6. Continued.

percentage of pervious surface (signified by DRYHRS as an independent variable), and the multiple-dwelling residential catchment consists of soil with a higher infiltration rate (soil group A) than the other two catchments (soil group B), which is signified by the independent variable MAX20.

The regression equation for the commercial catchment for rainfall totals greater than 0.17 inch calculates a runoff volume which exceeds the rainfall total. This anomaly is due to data collection inaccuracies as discussed earlier. Only data for the first rain season for the commercial catchment were used in the regression analysis because of the inaccuracies of the flow record in the second rain season caused by the construction activities adjacent to the catchment as discussed in Oltmann and others (1987).

The percent of variation explained for the industrial catchment (75 percent) is lower than the other three catchments (94 percent and higher) because the industrial catchment has a larger percentage of idle and vacant land (table 1) and has more depression storage compared to the other three catchments. Field observations during storms revealed a larger quantity of depression storage in the industrial catchment compared to the other three catchments, especially in the storm-drain system. Depression storage also was observed on some of the vacant industrial lands.

Rainfall-Runoff Response

The magnitude and response of runoff from a catchment are related to the amount of effective impervious area in the catchment. Effective impervious areas drain directly to water conveyance channels that route the runoff to the monitoring location. Noneffective impervious areas drain to pervious areas and therefore do not contribute to the runoff hydrograph unless infiltration demands have been met.

If all of the impervious areas in a catchment are effective impervious areas, the percentage of rainfall that drains off a catchment (rainfall-runoff coefficient multiplied by 100) will be about equal to the percentage of impervious area in the catchment. Comparison of the mean rainfall-runoff coefficients for each catchment (table 5) and the percentage of impervious area (table 1) indicates that a large part of the impervious area for the two residential and industrial catchments are not effective impervious areas. The impervious area for the commercial catchment is almost entirely an effective impervious area.

To graphically compare rainfall-runoff response for the four catchments, flow hydrographs and rainfall bar graphs (hyetographs) for a typical storm (November 17, 1981) are shown in figure 7. The hydrographs show that the highly impervious commercial catchment responds faster to rainfall than the other catchments, which results in steeper rising and falling hydrograph limbs, and higher peak flows. The high percentage of effective impervious area for the commercial catchment also produces a much greater runoff volume even though the industrial and single-dwelling residential catchments have larger drainage areas.

Rainfall Quality Samples

Numerous storm-composite (bulk) rainfall samples were collected on a storm basis at the industrial and single-dwelling residential sites during the 1981–82 and 1982–83 rain seasons. In addition, a third rainfall quality collection site was established at the project's laboratory (fig. 3) during the 1982–83 rain season. This third collection site was initiated because there was concern that the rainfall quality at the single-dwelling residential site might be affected by its proximity to the Fresno Airport (fig. 3), and that the rainfall quality at the industrial site might be affected by its surrounding environment. If the two concerns were true, neither site's data would be suitable for use in future studies to estimate rainfall quality for the remaining majority of the Fresno urbanized area. This does not imply that the laboratory rainfall data would be truly representative of the remaining urbanized area, but these data should not be affected by the above-mentioned interferences. The laboratory site was a rainfall quality site only; total rainfall data were not collected.

Rainfall quality usually will vary throughout a storm. The measurements made of a storm-composite sample could be considerably different from measurements of discrete samples of rainfall collected during that storm. This may be particularly true for pH. However, the objective was to obtain results that were representative of the entire storm. Therefore, the results represent rainfall event mean concentrations (EMC).

Statistical summaries of all the rainfall quality data including the number of samples and the mean, median, standard error of mean, standard deviation, maximum, and minimum values for analyzed constituents are presented for each of the three sites in tables 6 through 8.

Comparison of Rainfall Quality

Statistical testing was used to determine if rainfall quality (constituent concentrations) differed between the two rain seasons and among sampling sites. In order to determine which statistical comparison test would be used, the UNIVARIATE procedure of SAS (Helwig and Council, 1979) was used to evaluate the data distribution of the constituent concentrations. Depending on the number of samples, the UNIVARIATE procedure uses the Shapiro Wilk W-statistic ($N \leq 50$) or a modified version of the Kolmogorov-Smirnov D-statistic ($N > 50$) to test whether or not the data are normally distributed. If the data were not normally distributed, a nonparametric statistical procedure, the Kruskal-Wallis (chi-square approximation) test was used for testing. If the data were normally distributed, a parametric statistical procedure, ANOVA (analysis of variance) was used. Both tests are included in the NPAR1WAY procedure of SAS (Helwig and Council, 1979).

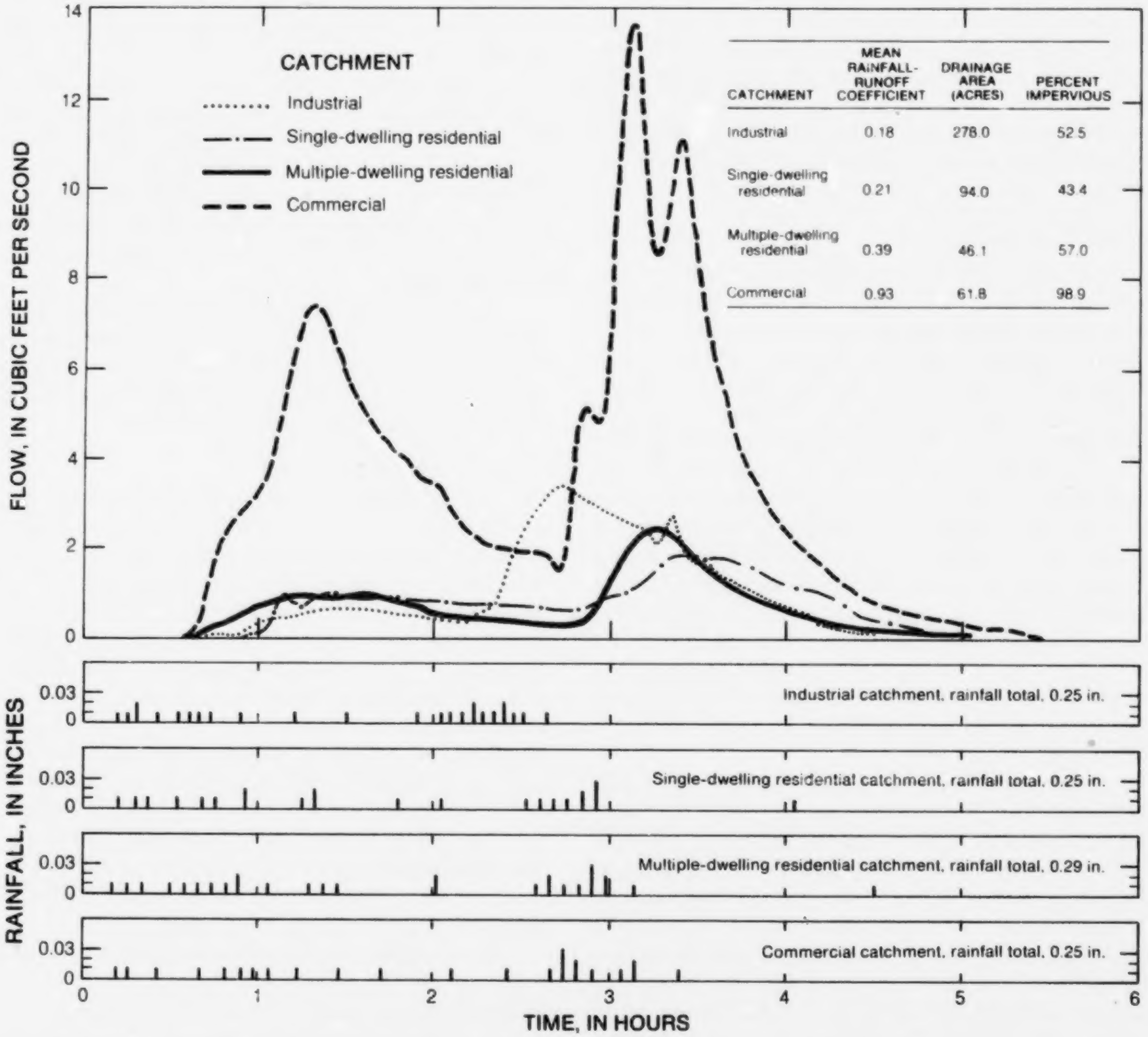
Results of the statistical comparison testing between rain seasons showed no significant difference ($\alpha = 0.05$) for any of the constituents measured at the single-dwelling residential site. At the industrial site, only dissolved phosphorus and dissolved organic carbon were significantly different between the first and second rain seasons. After this initial testing between years, all of the data from both years were combined into one data set for each site, except for the two constituents that differed between years at the industrial site. The results of testing between sites are shown in table 9. Most of the differences occurred between the industrial and single-dwelling residential sites. Schematic plots for four of the constituents that did show significant differences—pH, dissolved nitrogen ammonia, dissolved ammonia plus organic nitrogen, and phenols—are shown in figure 8.

The results shown in table 9 indicate that rainfall quality at the three different sites generally is comparable. However, microclimatic variations that occur in the urban area and localized air pollutants may affect rainfall quality in some areas. Of the five constituents that differed significantly between the industrial and single-dwelling residential sites, three—pH, dissolved nitrogen ammonia, and dissolved ammonia plus organic nitrogen—could conceivably result from industrial plant emissions being discharged in and near the industrial catchment. There is not enough evidence at this time to confirm this conclusion.

The overall quality of the rainfall probably is affected more by regional inputs such as those from the agricultural lands surrounding Fresno than by localized effects. This conclusion is strengthened by some results of pesticides analysis, which will be discussed later.

Computation of Rainfall Constituent Loads

Storm rainfall and runoff constituent loads were not computed for all of the monitored quality constituents listed in table 2. Rainfall loads were computed for the 15 constituents listed below (runoff loads also were computed for these



CATCHMENT	MEAN RAINFALL-RUNOFF COEFFICIENT	DRAINAGE AREA (ACRES)	PERCENT IMPERVIOUS
Industrial	0.18	278.0	52.5
Single-dwelling residential	0.21	94.0	43.4
Multiple-dwelling residential	0.39	46.1	57.0
Commercial	0.93	61.8	98.9

Figure 7. Flow hydrographs and hyetographs for each of four monitored catchments for a typical storm (November 17, 1981).

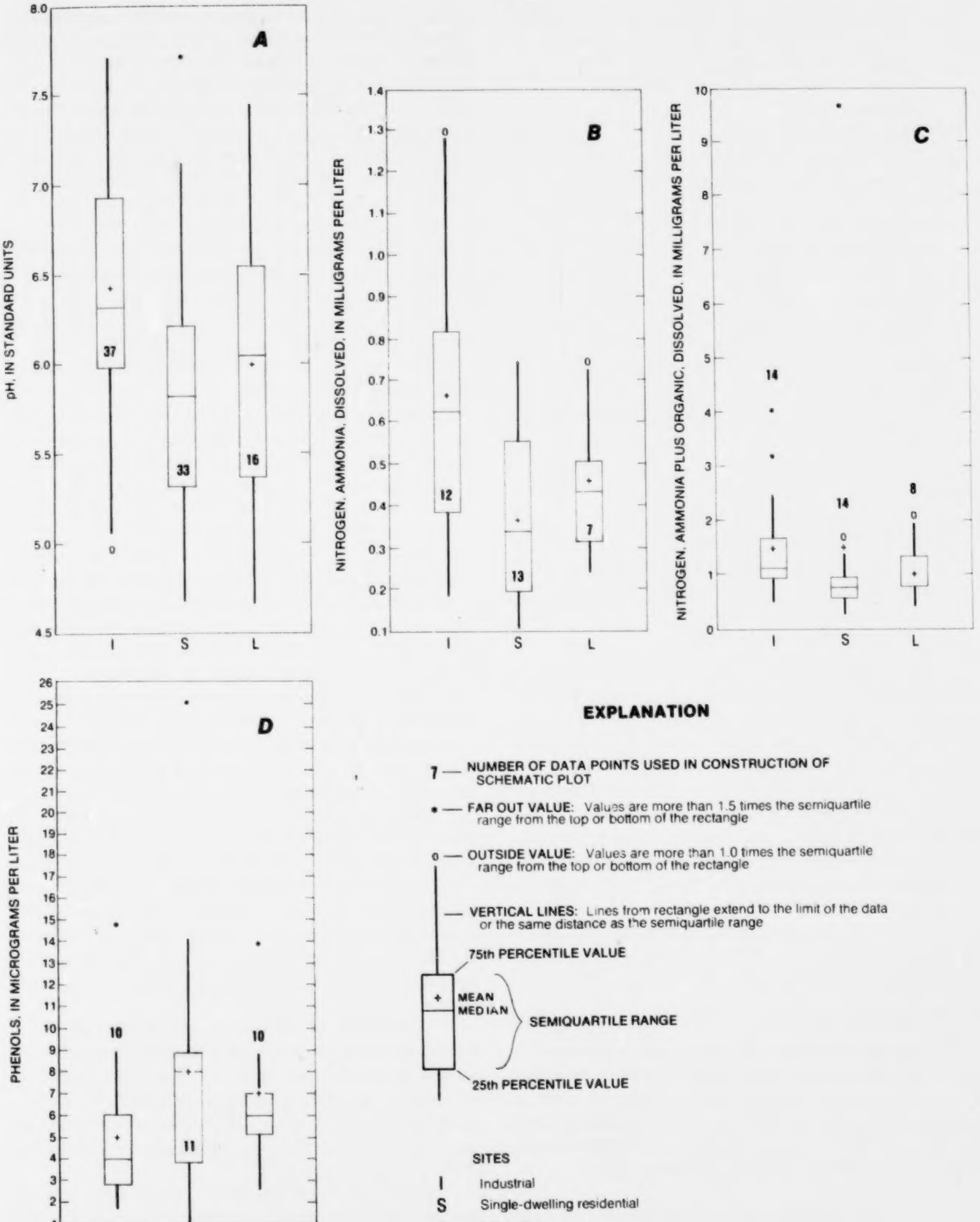


Figure 8. Four rainfall constituents that were determined to be significantly different. *A*, pH *B*, Dissolved nitrogen ammonia. *C*, Dissolved nitrogen (ammonia plus organic). *D*, Phenols.

15 constituents in addition to 3 other constituents; refer to "Computation of Runoff Constituent Loads" section):

- nitrogen, nitrite plus nitrate, dissolved
- nitrogen, ammonia plus organic, dissolved
- phosphorus, dissolved
- oxygen demand, chemical
- carbon, organic, dissolved
- aluminum, total recoverable
- arsenic, total
- chromium, total recoverable
- copper, total recoverable
- iron, total recoverable
- lead, total recoveraable
- manganese, total recoverable
- mercury, total recoverable
- nickel, total recoverable
- zinc, total recoverable

Rainfall constituent loads were computed using the following relation:

$$L=0.2266(R\times DA\times CONC),$$

where

L is rainfall load, in pounds;
R is rainfall total, in inches;
DA is catchment drainage area, in acres;
$CONC$ is constituent concentration, in milligrams per liter; and
0.2266 is units conversion factor.

The resultant load is the quantity of a constituent, in pounds, that fell on the catchment for a given storm. The constituent concentration is the laboratory analyses concentration of the bulk rainfall sample collected for that storm (event mean concentration).

All the calculated storm rainfall constituent loads are given in tables 10 and 11. Loads were not computed for the laboratory site because rainfall quantity data were not available. Rainfall unit loads (for example, pounds per acre) were not computed or shown in the table because of the resultant very small numbers, and unit loads using square miles were possibly too large an extrapolation of the point data. Rainfall loads are compared to runoff loads in the "Comparison of Rainfall and Runoff Quality Data" section.

Runoff Quality Samples

Numerous discrete runoff samples were collected at the four monitoring sites during the two rain seasons of the study. Statistical summaries of these data including number of samples, mean, median, standard error of mean, standard deviation, maximum, and minimum are presented for each of the four catchments in tables 12 through 15.

Comparison of Catchment Runoff Quality Using Discrete Sample Data

Comparison of land-use runoff quality was done by applying statistical tests to the discrete runoff constituent concentration data. In order to compare catchment runoff quality, only sample results for common storms should be compared. However, because of the external electromagnetic field interference at the single-dwelling residential site during the first rain season and the construction activities adjacent to the commercial catchment during the second rain season, only a few storms have usable sample data for all four catchments (Oltmann and others, 1987). Therefore, in order to provide a larger data base for statistical comparison purposes, two data sets were formed each using storms common to only three catchments. The first data set included five storms common to the industrial, multiple-dwelling residential, and commercial catchments (Nov. 17, 1981; Jan. 4, 1982; Mar. 9–10, 1982; Mar. 10–11, 1982; Mar. 25–26, 1982). The second data set included eight storms common to the industrial, single-dwelling residential, and multiple-dwelling residential catchments (Nov. 12, 1981; Nov. 17, 1981; Mar. 9–10, 1982; Mar. 10–11, 1982; Mar. 25–26, 1982; Sept. 24, 1982; Oct. 25, 1982; Jan. 18, 1983). Statistical comparison testing was applied to each of these data sets with the results used to implicitly compare the single-dwelling residential and commercial catchments. Therefore, if there was no statistical difference between the data properties and values for a particular constituent for the three catchments in data set 1, and no statistical difference for the same constituent for the three catchments in data set 2, then the assumption could be made that there was no statistical difference of the data properties and values for that particular constituent between the single-dwelling residential and commercial catchments.

The same statistical procedures described previously for rainfall quality were used for these analyses.

The runoff quality constituents that were determined to have no statistical difference ($\alpha=0.05$) in concentration values for the catchments are shown in table 16. Two significant conclusions can be drawn from the data in table 16: (1) The two residential catchments are quite similar with respect to quality of runoff (50 of the 57 constituents are similar), and (2) the industrial catchment runoff is quite different from the other three catchments (10 constituents are similar with at least one of the other catchments). The schematic plots for selected constituents shown in figure 9 present a visual comparison between catchments of the runoff quality constituent data.

Typical plots of nutrient data are shown in figure 9*A*, *B*; both show the conclusions stated above. Although some nutrient data for the commercial catchment are not statistically similar to any of the other three catchments, the plots do show that nutrient data for the commercial catchment are more representative of the two residential catchments than of the industrial catchment.

Typical plots of metal data are shown in figure 9*C–E*. The data for total recoverable copper and total recoverable zinc (plots not shown in fig. 9) are similar to total arsenic (fig. 9*C*); each shows markedly higher concentrations for the industrial catchment. The information shown in figure

9D, total recoverable lead, is unique in that it shows the industrial catchment concentrations to be lower than the other three catchments. The data for plots of total recoverable aluminum, manganese, and nickel (not shown in fig. 9) show the same relation to total recoverable iron (fig. 9*E*) of high concentrations at the industrial and multiple-dwelling residen-

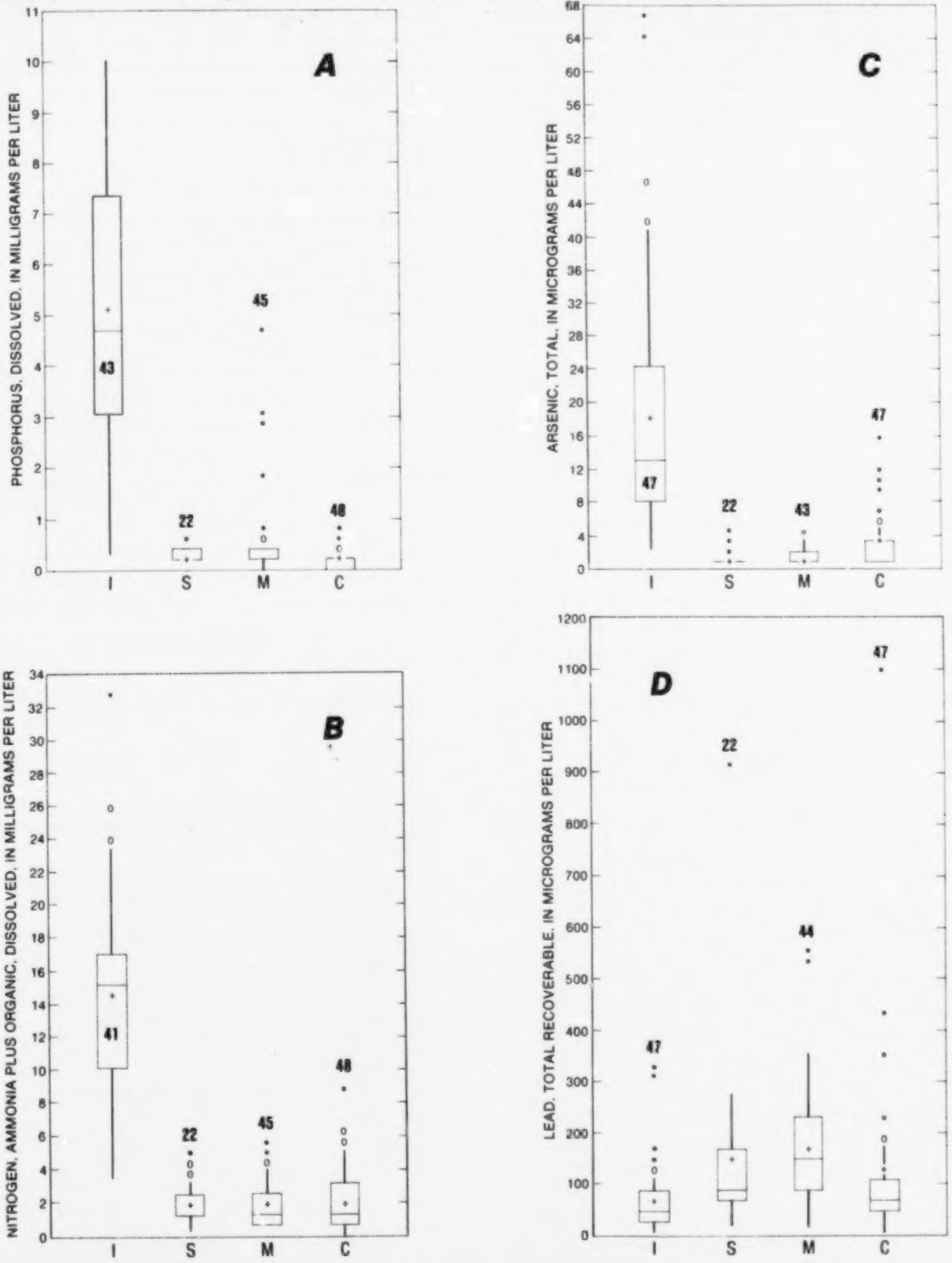


Figure 9. Comparison between catchments for selected constituents using runoff quality data. *A*, Dissolved phosphorous. *B*, Dissolved nitrogen (ammonia plus organic). *C*, Total arsenic. *D*, Total recoverable lead. *E*, Total recoverable iron. *F*, Suspended sediment. *G*, Chemical oxygen demand. *H*, Biochemical oxygen demand.

tial catchments and low concentrations at the single-dwelling residential and commercial catchments. Comparing these plots with the suspended sediment (fig. 9*F*) indicates the same relation. Both the industrial and multiple-dwelling residential catchments have undeveloped land where soil erosion could take place, thus causing the higher suspended-sediment

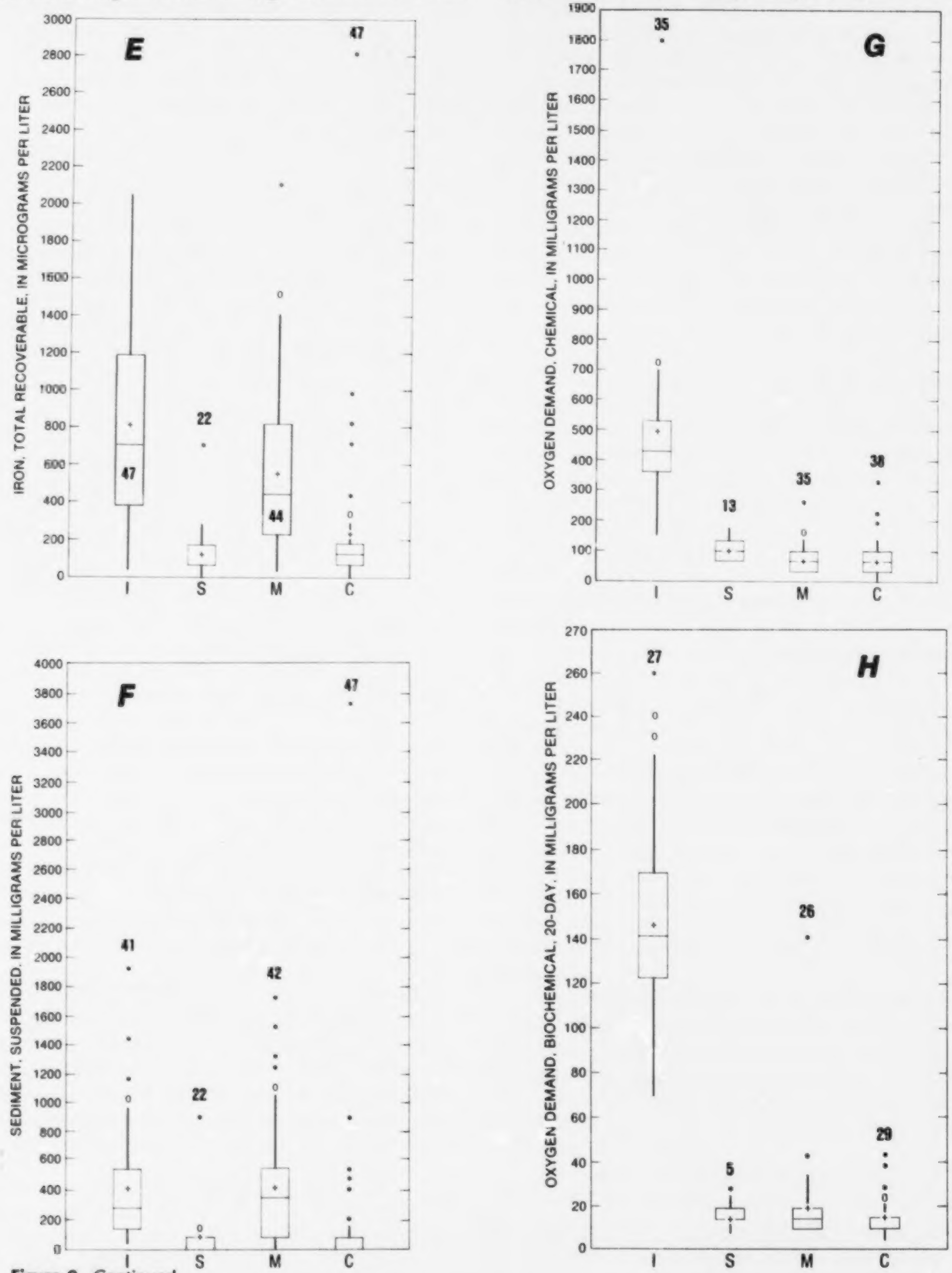


Figure 9. Continued.

concentrations and metal concentrations because these metals are abundant in soils. Therefore, these metal data may not be typical of runoff from a fully developed multiple-dwelling residential or industrial catchment. Data shown for chemical oxygen demand (fig. 9*G*) and 20-day biochemical oxygen demand (fig. 9*H*) are typical of most constituent concentration plots, with the industrial catchment concentrations far exceeding the concentrations at the other three catchments.

The cations (calcium, alkalinity, magnesium, sodium, and potassium) and the anions (chloride, sulfate, bicarbonate, nitrate, and ammonia) are shown for each catchment in figure 10. These pie diagrams show average ion concentrations in milliequivalents per liter (meq/L) for all analyses for each catchment. In an ideal situation, the total cations in milliequivalents per liter will equal the total anions in the same units within 1 or 2 percent. In instances where the anion plus cation total is less than about 5.00 meq/L, larger percentage errors sometimes occur (Hem, 1970). Urban runoff samples are particularly troublesome because chemical transformations are occurring rapidly as the dilute rainfall rapidly mixes with solids on the ground. This explains the slight cation-anion imbalances seen in the pie diagrams. In spite of the imbalances, comparisons can be made of the general water types discharging from each catchment.

As with other inorganic and organic constituents, a difference between the industrial catchment and the other three catchments is noticeable. The predominance of sodium and chloride from the industrial catchment contrasts sharply with the more balanced ionic composition of runoff from the single-dwelling residential, multiple-dwelling residential, and commercial catchments. The large proportion of sodium chloride in solution from the industrial catchment is indicative of the unusual conditions that exist in an industrial catchment. For the other three catchments, the cation calcium and the anion bicarbonate account for about 50 percent of the total composition, and the ionic composition for each catchment is similar.

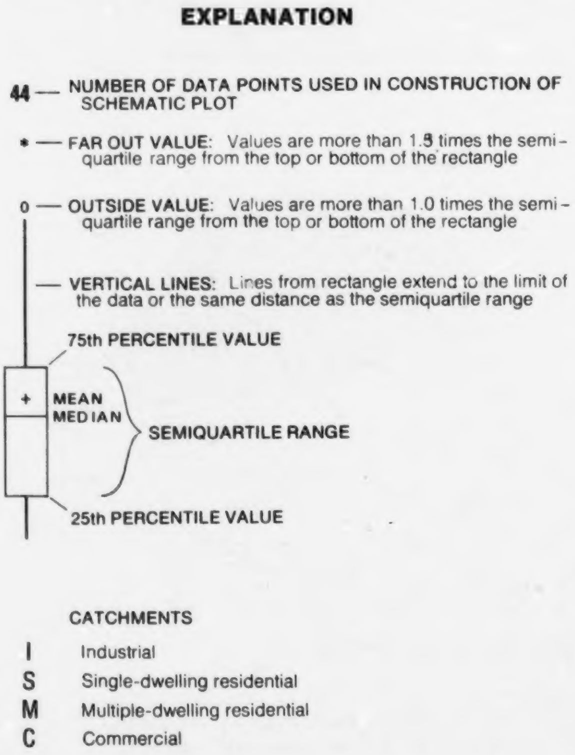

EXPLANATION
44 — NUMBER OF DATA POINTS USED IN CONSTRUCTION OF SCHEMATIC PLOT
* — FAR OUT VALUE: Values are more than 1.5 times the semiquartile range from the top or bottom of the rectangle
o — OUTSIDE VALUE: Values are more than 1.0 times the semiquartile range from the top or bottom of the rectangle
— VERTICAL LINES: Lines from rectangle extend to the limit of the data or the same distance as the semiquartile range
75th PERCENTILE VALUE
+
MEAN
MEDIAN
SEMIQUARTILE RANGE
25th PERCENTILE VALUE
CATCHMENTS
I Industrial
S Single-dwelling residential
M Multiple-dwelling residential
C Commercial

Figure 9. Continued.

Comparison testing of the fecal-coliform bacteria data was not done because of the small unbalanced data set, and the uncertainty of the data. The 6-hour sampling-to-processing time constraint for fecal-coliform bacteria caused numerous logistic problems that limited the number of samples that could be analyzed for fecal-coliform bacteria. When samples were collected and analyzed within the 6-hour time limit, a large percentage resulted in culture plates with colonies too numerous to count. The variability of urban runoff made it difficult to select a range of sample volumes that would result in an ideal colony count.

During the first rain season only, 26 dibromochloropropane (DBCP) samples were collected from the four catchments. The analytical results for 21 of the 26 samples were less than the detection limit of 0.003 microgram per liter (μg/L). Each catchment had at least one sample concentration greater than the detection limit, with the exception of the commercial catchment that had two results greater than the detection limit, including the 0.01-μg/L maximum.

During the second rain season only, 22 volatile organic samples were collected from the four catchments. The samples were analyzed for benzene, chlorobenzene, and ethylbenzene. The analytical results did not produce any concentrations greater than the detection limit of 1.0 μg/L.

Variation of Constituent Concentrations Throughout a Storm

Most constituent concentrations were highest in the initial runoff of a storm. Constituents accumulated on the catchment since the previous storm and located near the monitoring site are washed off by the initial storm runoff. Therefore, the initial runoff results in high constituent concentrations because of the low runoff volumes that transport the collected constituents. Constituents that have collected on the catchment at greater distances from the monitoring site also are first transported by small quantities of initial runoff, but usually are well diluted by the time they reach the monitoring site resulting in lower constituent concentrations. Therefore, high constituent concentrations associated with initial washoff are a localized phenomenon.

Constituent concentrations vary during a runoff event depending upon the type of constituent. Nutrient concentrations generally are highest at the beginning of storm runoff and then steadily decrease throughout the runoff event irrespective to variation in flow (fig. 11). Metal concentrations generally are higher at the beginning of runoff, but vary thereafter depending on velocity. This variation probably is because metals are associated with sediment particles (Gibbs, 1977), and larger sediment particles are transported by higher velocities. Therefore, the highest metal and sediment concentrations usually are found on the rising limb of a hydrograph (fig. 11). Chemical oxygen demand, 20-day biochemical oxygen demand, and specific conductance (related to ion concentrations) all vary throughout a hydrograph similar to nutrient constituents (fig. 11).

The plots shown in figure 11 are typical of all the monitored catchments except for the industrial catchment, which did not demonstrate constituent concentration patterns

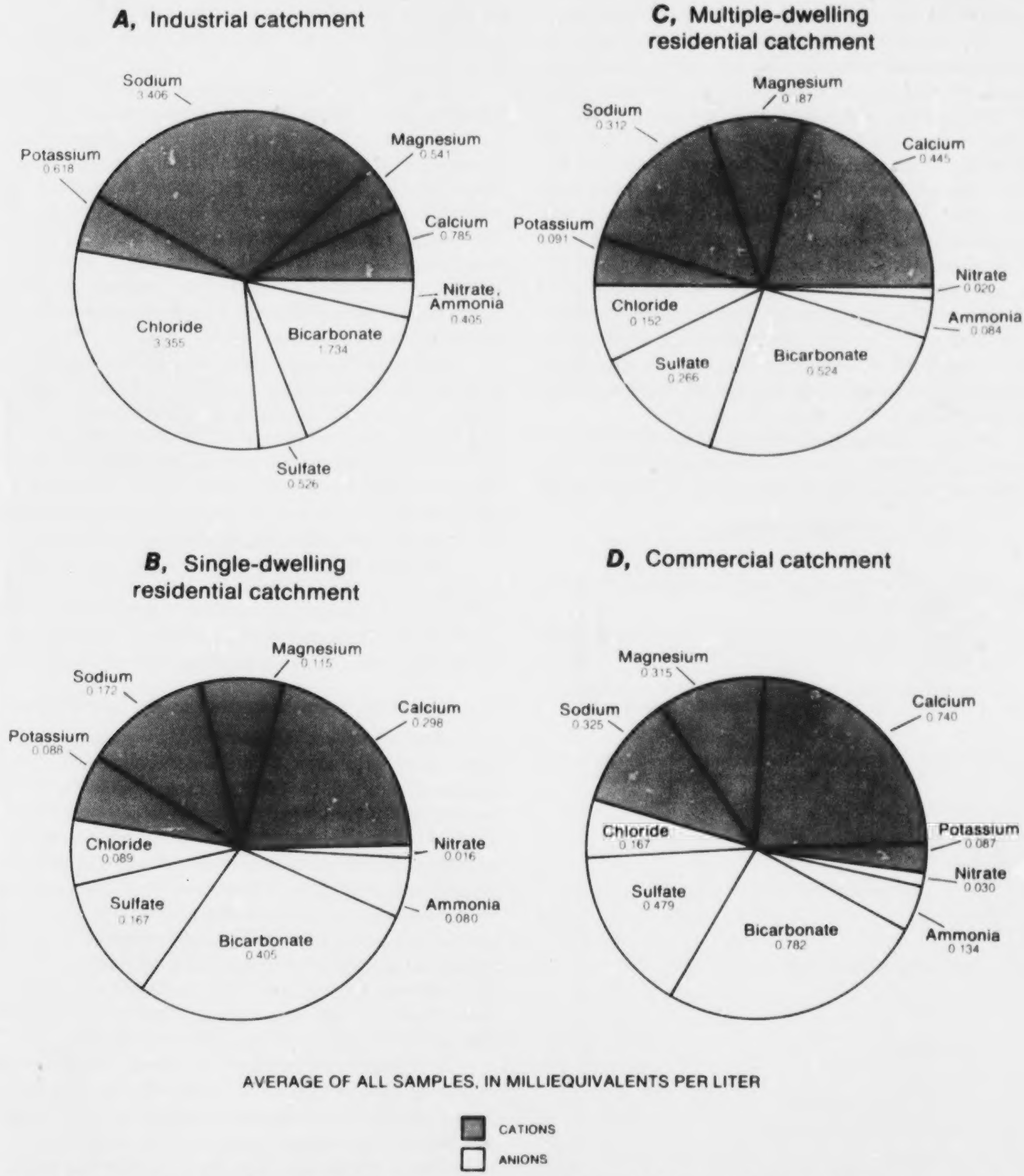


Figure 10. Average concentrations of dissolved major ions for runoff for each of four monitored catchments.

throughout a storm. A typical constituent concentration plot for the industrial catchment is shown in figure 12. The plot shows the highest concentrations of phosphorus and chemical oxygen demand occurred unexpectedly in the middle of the hydrograph and were not associated with a peak flow. Numerous high specific-conductance spikes were recorded for the industrial catchment during the study period, the largest of which occurred October 25, 1982, when the specific conductance rose from 666 to 9,960 microsiemens per centimeter (μS/cm) in 8 minutes, and then receded to 1,025 μS/cm 24 minutes later. These random concentration spikes were common for the industrial catchment and

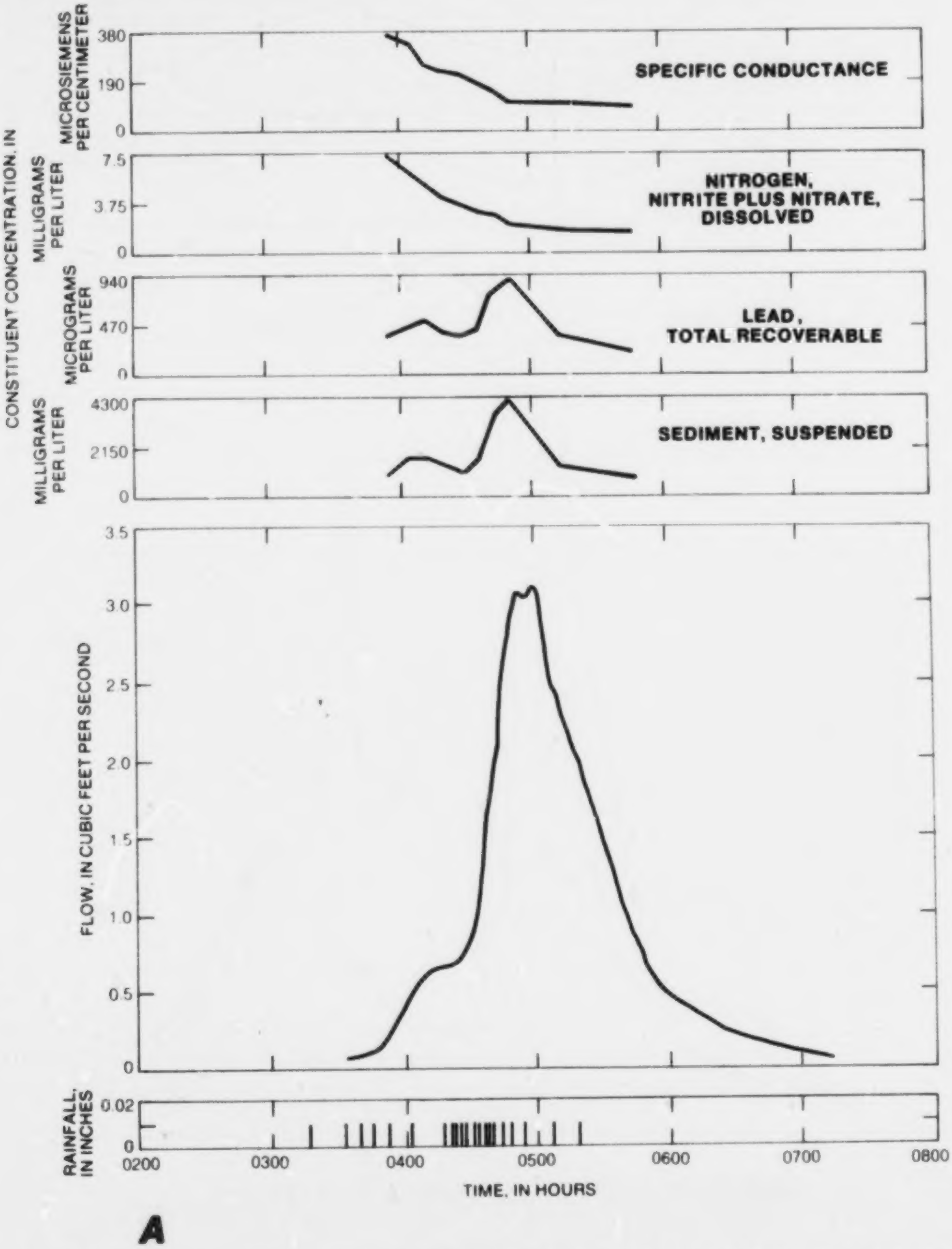


Figure 11. Typical constituent concentration plots and flow hydrographs. *A*, Multiple-dwelling residential catchment, September 24, 1982. *B*, Multiple-dwelling residential catchment, January 18–19, 1983. *C*, Commercial catchment, November 17, 1981.

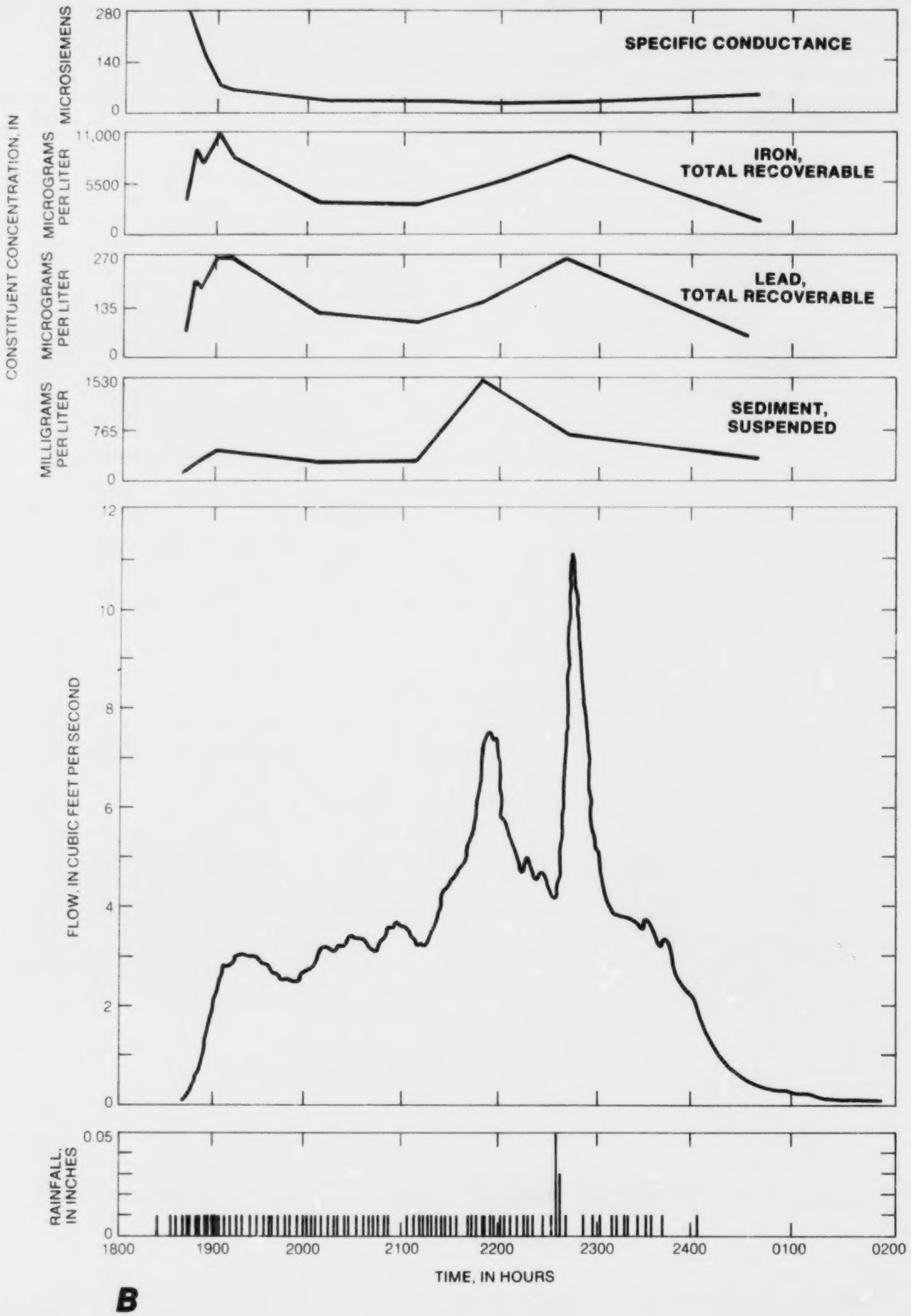


Figure 11. Continued.

probably were due to runoff from various point sources in the catchment. The arrival time was therefore dependent on the travel time between the point source and the monitoring point.

On January 11, 1983, an attempt was made to verify that the high constituent concentrations collected at the beginning of a storm are associated with catchment washoff and are not a result of flushing the storm-drain monitoring pipe of residue deposited since the last storm. The test consisted of simulating storm runoff at the multiple-dwelling residential site by discharging fire-hydrant water into the monitoring storm-drain pipe at the point where storm runoff enters the pipe. Samples were collected using the automatic sampling equipment in the same manner as if there was actual

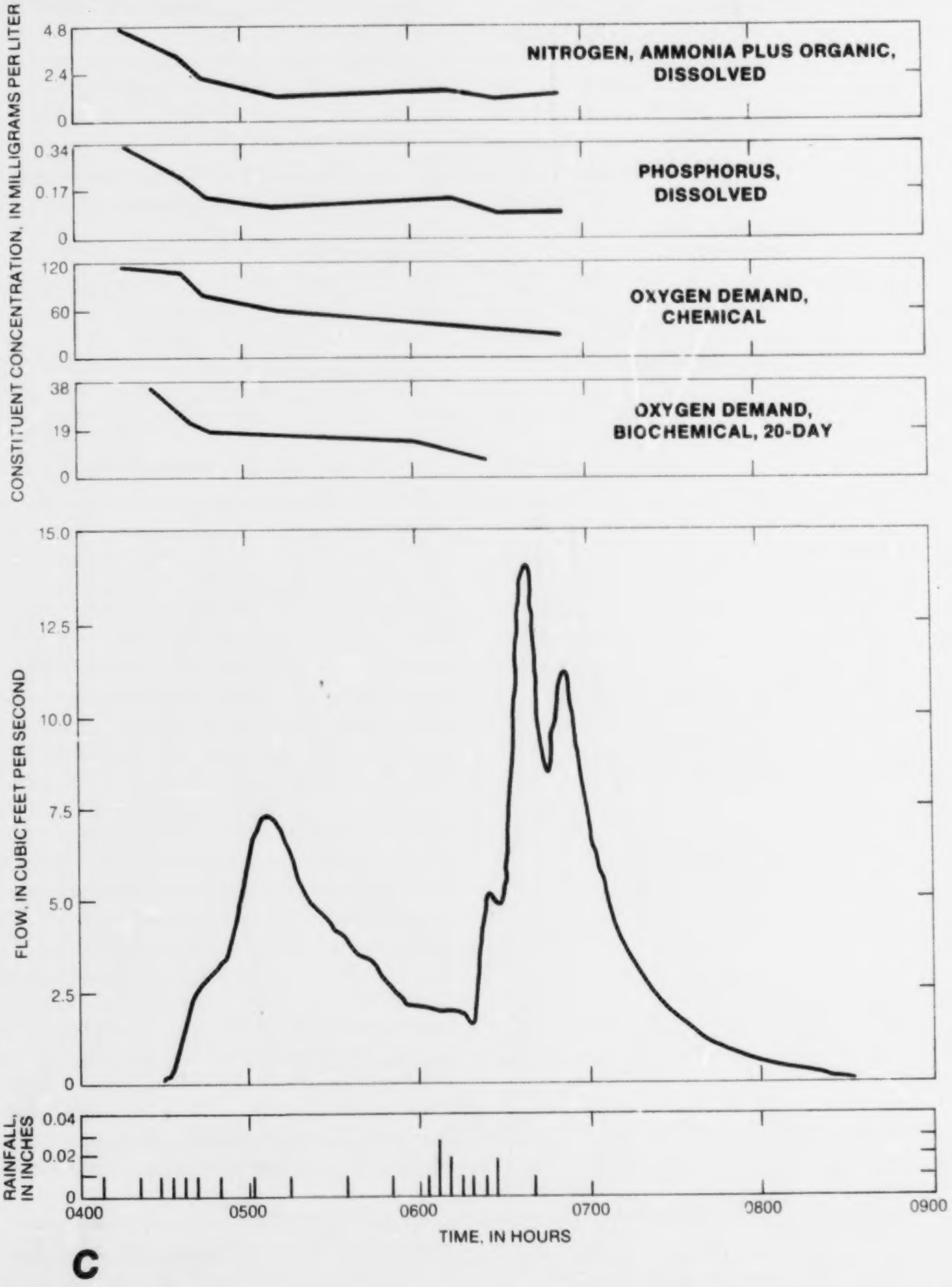


Figure 11. Continued.

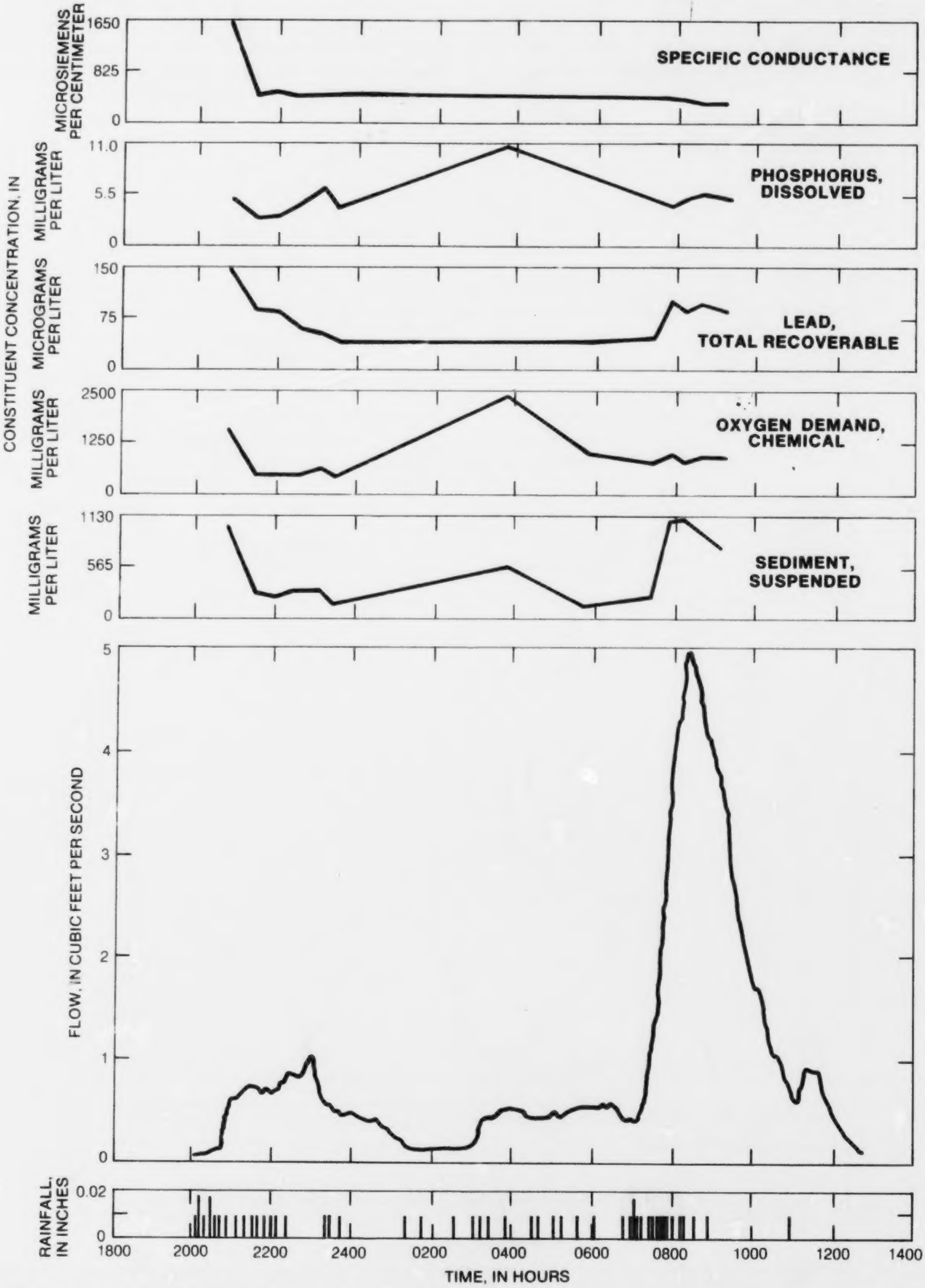


Figure 12. Typical constituent concentration plots and flow hydrographs for industrial catchment, November 12–13, 1981.

storm runoff. The first two collected samples along with the seventh sample (3-minute collection interval between samples) were sent to the laboratory for analysis of assorted nutrient and metal constituents. The seventh sample was selected as a control sample representative of the quality of the hydrant water. Comparing the laboratory results of the first two collected samples and the control sample indicated minimal differences in concentrations. Specific-conductance readings taken of all seven collected samples also showed minimal differences. The first hydrant water to reach the monitoring point was observed to be murky, but by the time the flow was deep enough to submerge the automatic sampler intake, the water was clear.

The results of this one-time test indicate that constituent concentrations for samples collected during storms probably are not biased by storm-drain pipe residue. Although this test was done at only one location, the results are believed to be transferable to the industrial and commercial sites because their storm-drain pipes and monitoring systems were similar to the multiple-dwelling residential site. This conclusion is not transferable to the single-dwelling residential site because the storm-drain pipe generally was full of water; tests were not made for this site.

Regression Analysis of Constituent Concentrations

Simple linear regression analysis was used to investigate possible relations between constituent concentrations for each catchment. This was done using the discrete sample data and the REG procedure of SAS (Helwig and Council, 1979). Relations between specific conductance and constituent concentrations also were investigated with the intent of using the relations with specific-conductance data for storms that did not have laboratory-analyzed constituent concentrations. The estimated concentrations then were to be used in conjunction with runoff data to calculate storm constituent loads (refer to "Computation of Runoff Constituent Loads" section) for use in additional data analysis.

The regression analysis results provided relations between nutrient species concentrations, and between specific conductance and nutrient, alkalinity, and dissolved-solids concentrations for all catchments except the industrial catchment (table 17). Relations for the industrial catchment could not be determined because of unexplained variance in the specific-conductance data. Determination of relations between dissolved and total recoverable metal concentrations, and relations between specific conductance and metals, chemical oxygen demand, and dissolved and suspended organic carbon concentrations were attempted but produced no usable results except for the specific conductance and chemical oxygen demand relation shown in table 17 for the single-dwelling residential catchment.

Before developing the nutrient and specific conductance relations, initial washoff samples for all storms were eliminated from the data set. Initial concentration plots of specific conductance and nutrient concentrations indicated that a linear relation existed between the constituents, but that there also were several outlier data points that usually plotted to the right of the indicated relation line (fig. 13). Further analysis revealed that most of these outlier data were initial washoff samples, indicating that the relation does not apply during this period. These data were omitted in order to avoid having these few outlier data points that result from a small part of the total hydrograph affect the calculation of the relation that would be applied to estimate concentrations for the entire storm hydrograph. The omission of these initial washoff data points produces a relation that estimates an initial washoff nutrient concentration that probably is higher than what would be measured. However, the error associated with eliminating initial washoff sample points has a small effect on the computed total storm constituent load.

A simple linear relation did not adequately fit the dissolved nitrite plus nitrate and specific-conductance data for the single-dwelling residential catchment. Therefore, as shown in table 17, a polynomial equation was found to provide the best fit. This was the only constituent or catchment where a nonlinear relation with specific conductance occurred. Also for the single-dwelling residential catchment, one relation for each rain season was determined for dissolved ammonia plus organic nitrogen and specific conductance. These relations were found to be statistically different ($\alpha = 0.05$).

Only the first rain season data were used for developing the relations for the commercial catchment. The second rain season's data were not used because of possible adverse effects to the data caused by the construction activity adjacent to the commercial catchment (Oltmann and others, 1987).

The regression relations and the 95-percent prediction confidence limits for specific conductance and dissolved phosphorus, dissolved ammonia plus organic nitrogen, dissolved nitrite plus nitrate, and dissolved solids are shown

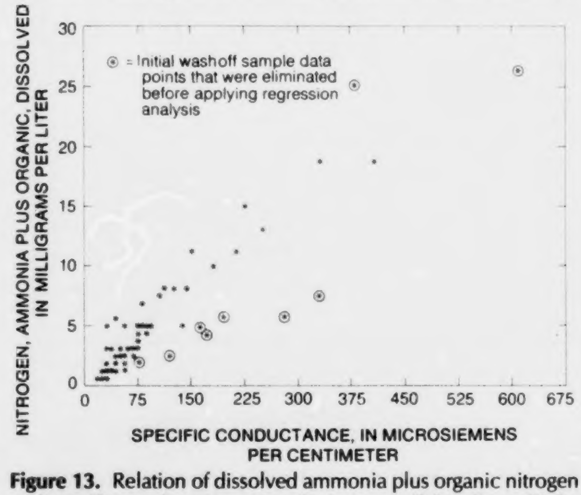


Figure 13. Relation of dissolved ammonia plus organic nitrogen and specific conductance using discrete runoff data for multiple-dwelling residential catchment.

graphically in figures 14 through 16. For the nonlinear relation between specific conductance and dissolved nitrite plus nitrate for the single-dwelling residential catchment, the predicted dissolved nitrite plus nitrate, calculated from the polynomial equation shown in table 17, is plotted against the measured dissolved nitrite plus nitrate. These relations were used in conjunction with specific-conductance readings (Oltmann and others, 1987, table 14) to estimate constituent concentrations for use in calculating storm constituent loads.

Computation of Runoff Constituent Loads

Storm event constituent loads were computed by using runoff data and one of the three following approaches:

1. Discrete laboratory constituent concentration data and the LOADS computer program documented by Doyle and Lorens (1982).
2. Estimated constituent concentration data and the LOADS computer program.
3. Laboratory flow-weighted composited samples.

Storm-runoff constituent loads were computed for the 15 constituents for which rainfall loads were computed in addition to loads for suspended sediment, suspended organic carbon, and dissolved solids. Runoff pesticide loads were not computed because only one or two grab samples were collected per storm. The major ion pie diagrams shown in figure 10 also can be used in conjunction with the dissolved-solids loads to provide estimates of individual ion unit loads.

The LOADS program computes a constituent load assuming that the constituent concentration varies linearly between known concentration data points. This may not be true for all cases, but if there are adequate concentration data covering the entire runoff hydrograph, the assumption is within acceptable practice. The assumption may be more precarious when using metals and suspended-sediment data because of the variation of these constituent concentrations with velocity, whereas most other constituent concentrations tend to decrease uniformly throughout the hydrograph after initial washoff (fig. 11).

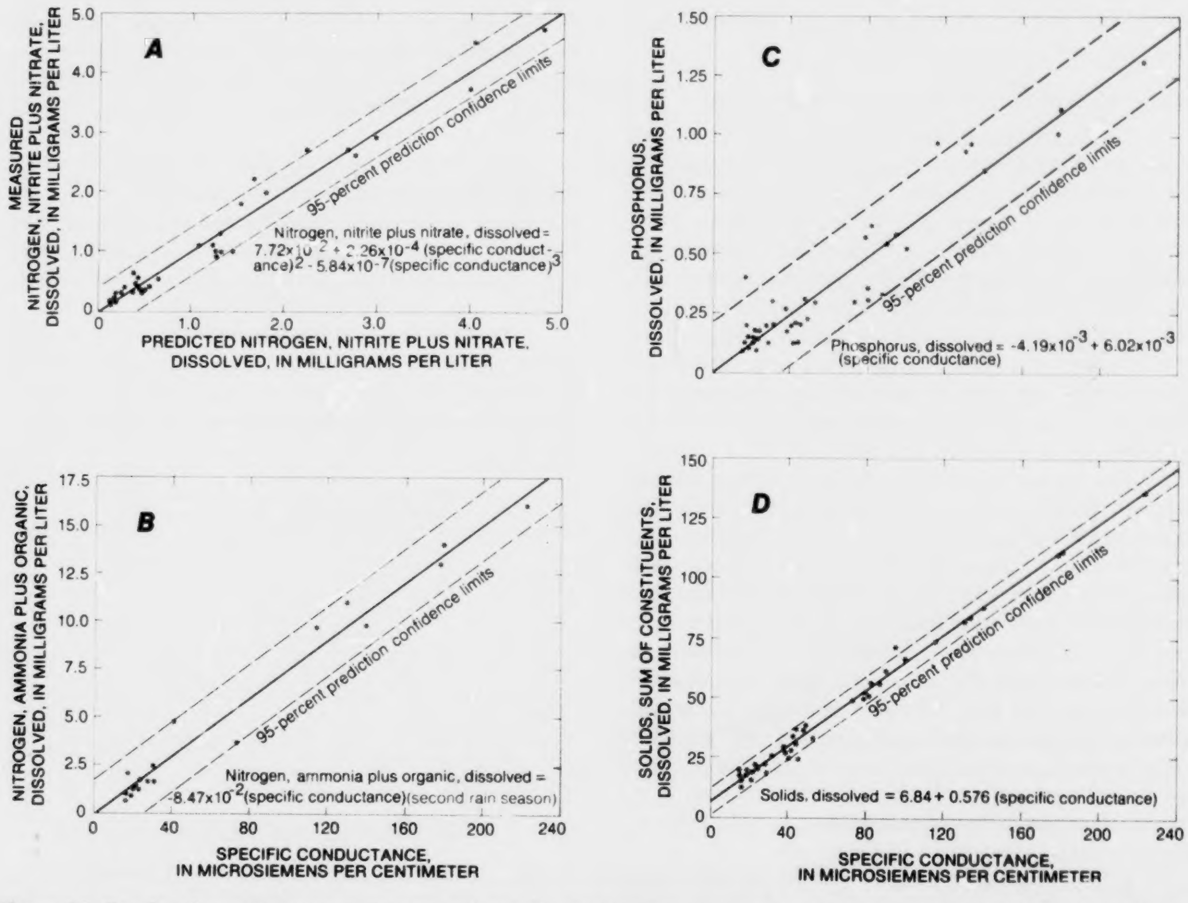


Figure 14. Results of constituent concentration and specific conductance regression analysis for the single-dwelling residential catchment. *A*, Dissolved nitrogen (nitrite plus nitrate). *B*, Dissolved nitrogen (ammonia plus organic). *C*, Dissolved phosphorus. *D*, Dissolved solids.

The LOADS program computes an interval load for each runoff data point by multiplying the interval runoff volume by the constituent concentration for that data point (fig. 17). The interval runoff volume is calculated by multiplying the runoff rate by the data-record interval. For calculating interval loads before the first known concentration point, the first known concentration value is used; for points after the last known concentration point, the last known concentration value is used. The summation of the interval loads equals the storm load.

The constituent concentration data used in the LOADS program were either the results of laboratory analysis or estimated. Constituent concentrations were estimated using regression equations and field measured specific conductance, as discussed in the previous section.

Due to analytical costs, not all monitored storms could have selected discrete samples collected throughout the hydrograph analyzed individually. Instead, the sampling equipment was programmed to collect flow-weighted samples (Oltmann and others, 1987) that were composited for each site upon completion of the storm and sent to the laboratory for analysis. The laboratory constituent concentration results, equivalent to the event mean concentration (EMC), then were multiplied by the computed storm-runoff volume (table 4) to produce a storm-runoff constituent load.

All computed constituent storm loads are listed in tables 18 to 21. The EMC's for storm loads not determined from composite samples were calculated by dividing the total constituent mass discharge (load) by the runoff volume. This calculation is an attempt to eliminate some data variability caused by storm volume variability.

Characterization and Regression Analysis of Constituent Event Mean Concentrations

The first step in characterizing constituent event mean concentrations (EMC) for each catchment was to determine which variables affect a constituent EMC. Therefore, the storm characteristic data in table 4 and the constituent EMC

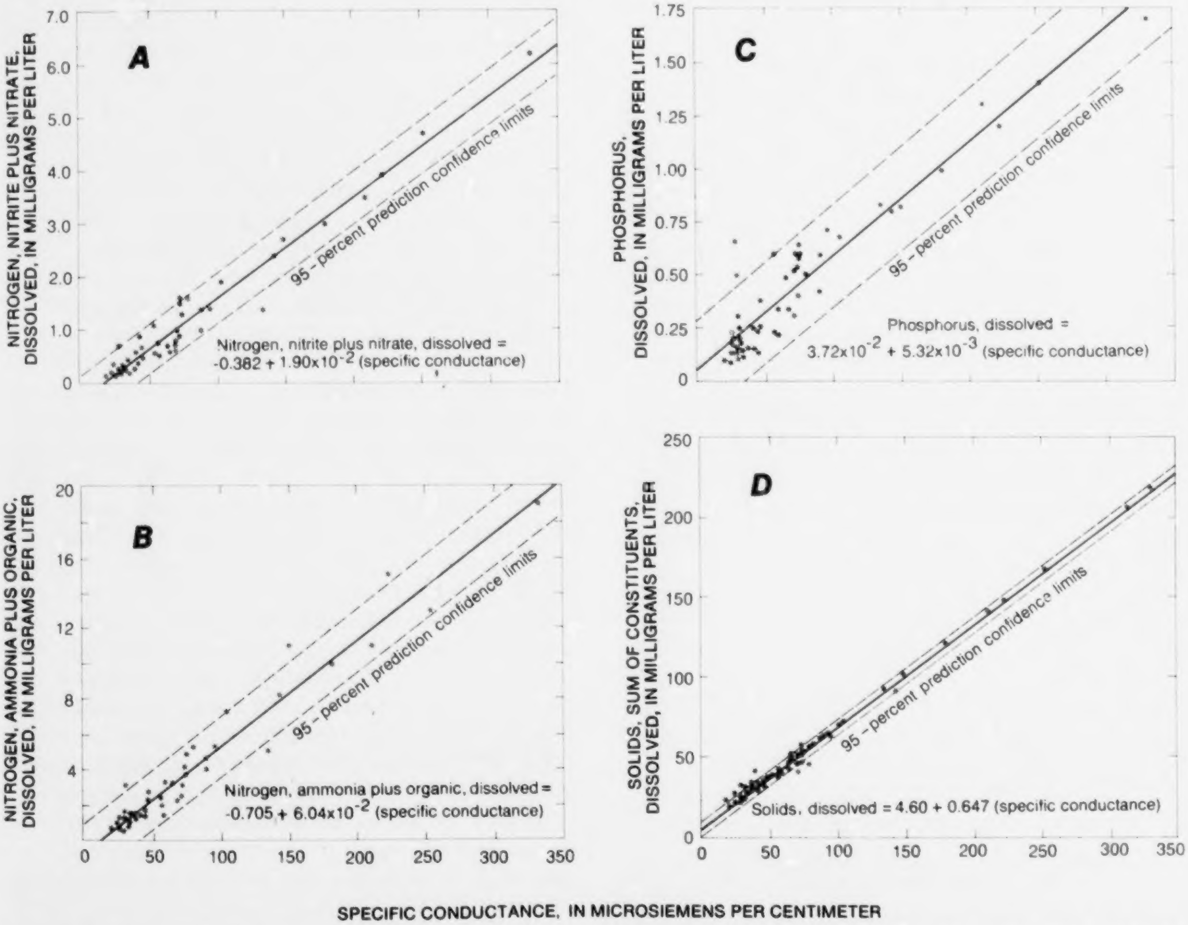


Figure 15. Results of constituent concentration and specific conductance regression analysis for the multiple-dwelling residential catchment. *A*, Dissolved nitrogen (nitrite plus nitrate). *B*, Dissolved nitrogen (ammonia plus organic). *C*, Dissolved phosphorus. *D*, Dissolved solids.

data in tables 18 to 21 were combined and plots generated which compare EMC's and (1) number of days since first storm of rain season (SFIRST), (2) number of dry hours since last storm (DRYHRS), (3) storm-runoff volume (RUNOFF), and (4) maximum 20-minute rainfall total (MAX20).

The EMC compared to number of days since first storm of rain season (SFIRST) plots for all but the industrial catchment show that the highest EMC's for most constituents occur for the first two or three storms of the year and then tend to become quasi-constant for the remainder of the rain season (fig. 18). This seems to indicate that at least two or three storms are required to wash off the constituents that have accumulated on the catchment throughout the dry months (usually May through September) preceding the rain season. All three nutrient species plots showed this high early-storm EMC pattern as did the plots for dissolved solids and suspended sediment and most of the metal plots. The organic carbon, chromium, and mercury plots did not show any pattern, as did most of the industrial catchment plots.

The EMC compared to DRYHRS showed the expected trend of large EMC values associated with larger DRYHRS (fig. 19). This relation indicates that the catchment begins accumulating atmospheric dry deposition, vehicular deposition, and other sources of constituents immediately after a storm, and that the longer the time since the last storm, the more material available to be washed off.

The EMC compared to storm-runoff volume plots showed the inverse trend of smaller EMC values associated with larger runoff volumes (fig. 20). This relation indicates that if a small storm occurs that washes off only part of the accumulated pollutants, the EMC will be higher than if a large storm occurs washing off all the available pollutants. This difference in the EMC is a result of the greater degree of dilution associated with the larger runoff volumes. This

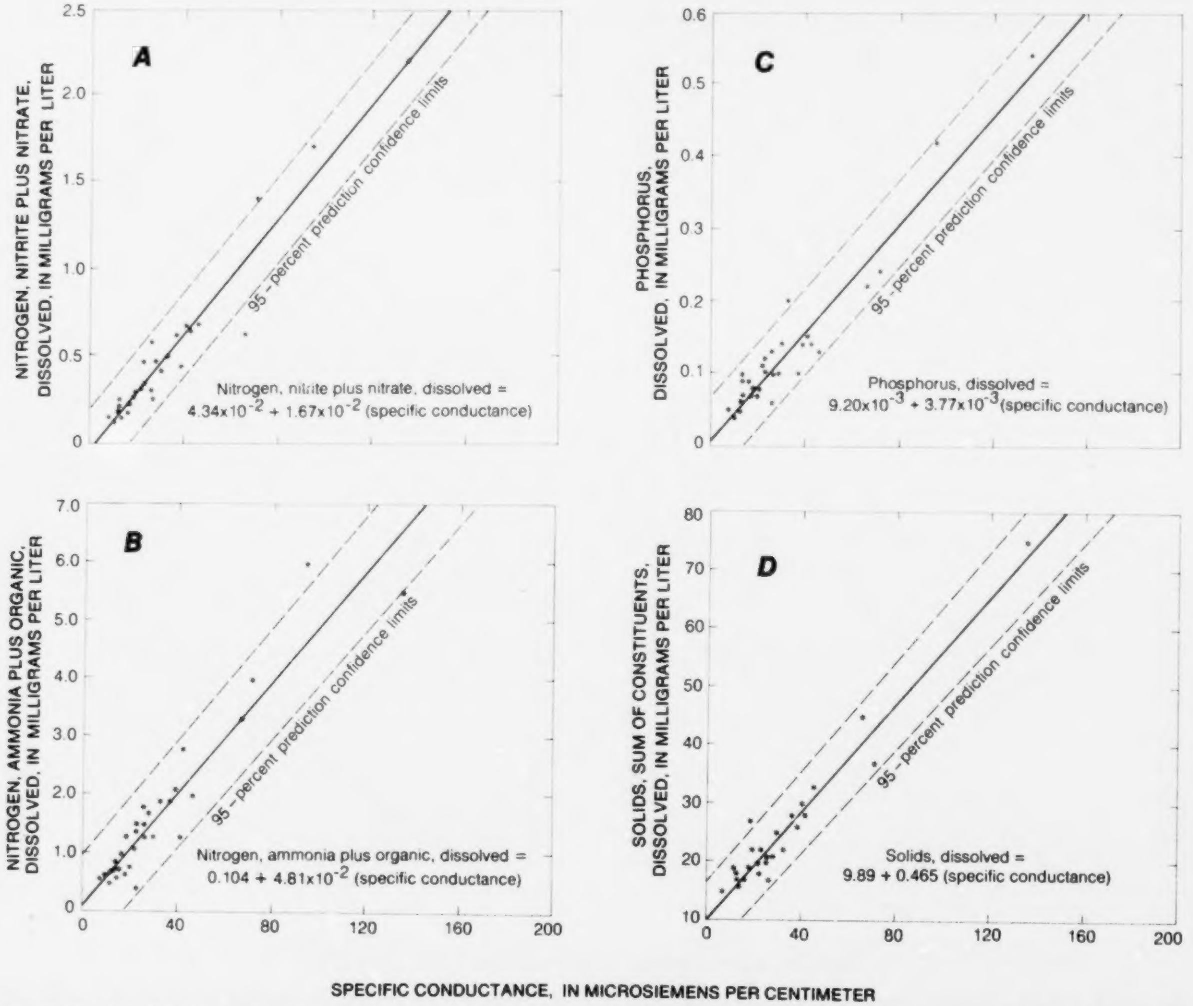


Figure 16. Results of constituent concentration and specific conductance regression analysis for the commercial catchment. *A*, Dissolved nitrogen (nitrite plus nitrate). *B*, Dissolved nitrogen (ammonia plus organic). *C*, Dissolved phosphorus. *D*, Dissolved solids.

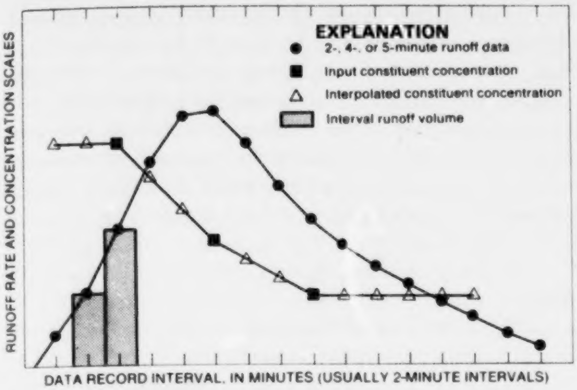


Figure 17. Computation of runoff load using LOADS program.

relation is particularly evident in the case of a highly impervious catchment, such as the commercial catchment where the accumulated constituents are rapidly washed off; as the storm progresses, the discrete constituent concentrations approach the concentrations of the rainfall. Therefore, the longer the rainfall continues, the larger the runoff volume and the lower the resulting EMC.

The EMC compared to maximum 20-minute rainfall total plots did not show any trends.

After completion of plotting the EMC data, multiple linear regression was used with constituent EMC's as dependent variables regressed against the independent variables SFIRST, DRYHRS, and storm-runoff volume. The intent of this regression analysis was to further characterize the EMC data, and to develop equations that could be used to estimate constituent EMC's for each of the different land-use types. The resultant estimated EMC could be combined with a storm-runoff volume estimated from the rainfall-runoff equations shown in figure 6 to produce constituent storm-runoff load estimates for use in future evaluation or design studies.

Before applying regression analysis, the one or two large EMC values associated with the first few storms of the rain season were eliminated from the catchment data sets. These large EMC values were eliminated because their inclusion would produce a regression equation that would provide a positive bias to EMC estimates calculated for most of a rain season's storms. In other words, the equations would be applicable for all but 2 or 3 of a rain season's 30 to 50 storms and would not be affected by those 2 or 3 storms. Because of the limited number of constituent EMC values for early rain season storms, development of EMC estimating equations for early rain season storms was not attempted.

The results of regression analyses indicated that all three independent variables were significant for some constituent EMC's for some catchments, and none of the variables were significant for other constituents. The independent variables for each catchment that were significant ($\alpha=0.05$) for all but 2 of the 18 constituents that have computed runoff loads are shown in table 22. EMC regression relations were not attempted for aluminum and manganese because of the small number of EMC values.

The predominant significant independent variables that affect nutrient EMC's are DRYHRS and RUNOFF. This indicates that material accumulates on the catchment with

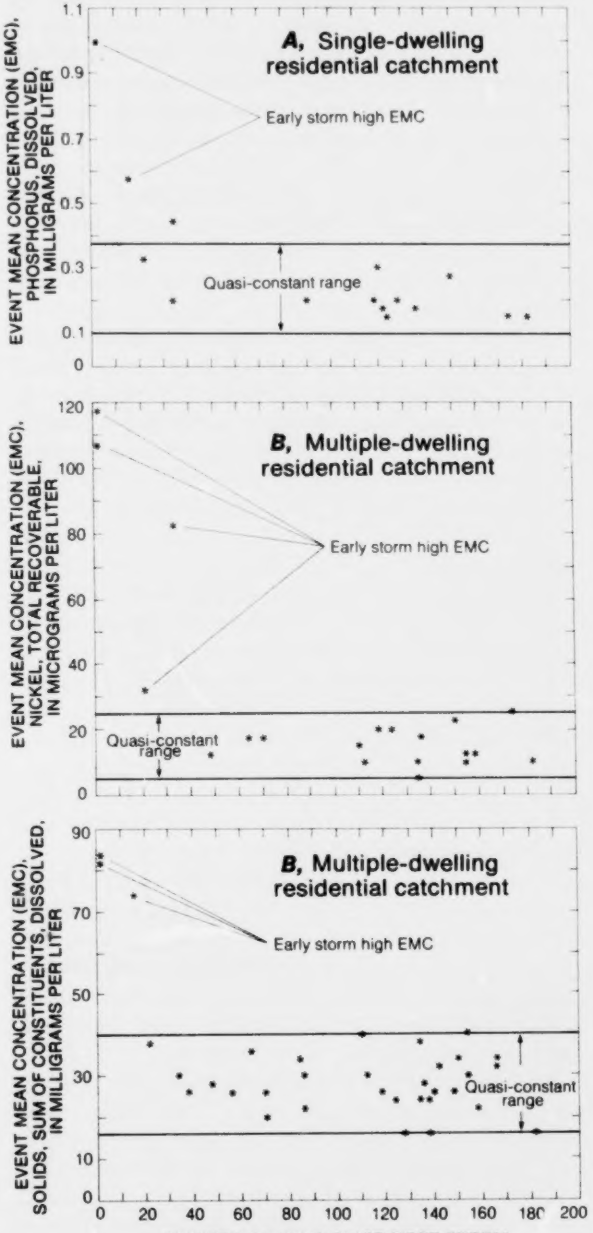


Figure 18. Comparison of constituent event mean concentrations and number of days since first storm of rain season. *A*, Single-dwelling residential catchment. *B*, Multiple-dwelling residential catchment.

respect to time between storms (DRYHRS), and is fairly easily washed off by a storm with the EMC dependent upon the volume of runoff that dilutes the accumulated material (RUNOFF).

SFIRST is the predominant significant independent variable for the metal EMC's for the two residential catchments. SFIRST also is the only significant variable for suspended sediment. Metals are transported in association with sediment particles (Gibbs, 1977). Therefore, the significance of SFIRST seems to indicate that the entire rain season may be needed to wash the summer accumulated sediments and metals from the catchment, because sediment is more difficult to transport than other constituents. The commercial catchment is washed of summer accumulated metals during the early storms. Afterwards, only a few metal EMC's (copper and zinc) are affected by DRYHRS, indicating that these metals accumulate on the catchment between storms.

The EMC's of total arsenic, total recoverable nickel, and dissolved organic carbon were not significantly related to the three independent variables for any of the four catchments. The significant independent variables for chemical oxygen demand, suspended organic carbon, and dissolved solids varied between catchments.

The results of the EMC estimate regression analysis for each catchment are listed in table 23 for each constituent that has a significant independent variable (table 22). The "percentage of variation explained" (R^2 adjusted for sample size) for many of the relations is fairly low; however, the estimated EMC provided by the regression equations are better estimates than using the mean of the EMC's. This is apparent by looking at how R^2 is computed:

$$R^2=(SS_{tot}-SS_{res})/SS_{tot},$$

where

SS_{tot} is the sum of the squares of the residuals about the mean of the dependent variable EMC, and

SS_{res} is the sum of the squares of the residuals about the EMC regression.

Therefore, the smaller SS_{res}, the better the relation, and the higher the percentage of variation explained. However, unless $SS_{res}=SS_{tot}$, the regression equation explains some of the variance of the dependent variable and is a better predictor of the dependent variable than using the mean of the dependent variable. The independent variables used in the regressions are shown to be statistically significant, but the R^2 values are low because there probably are other

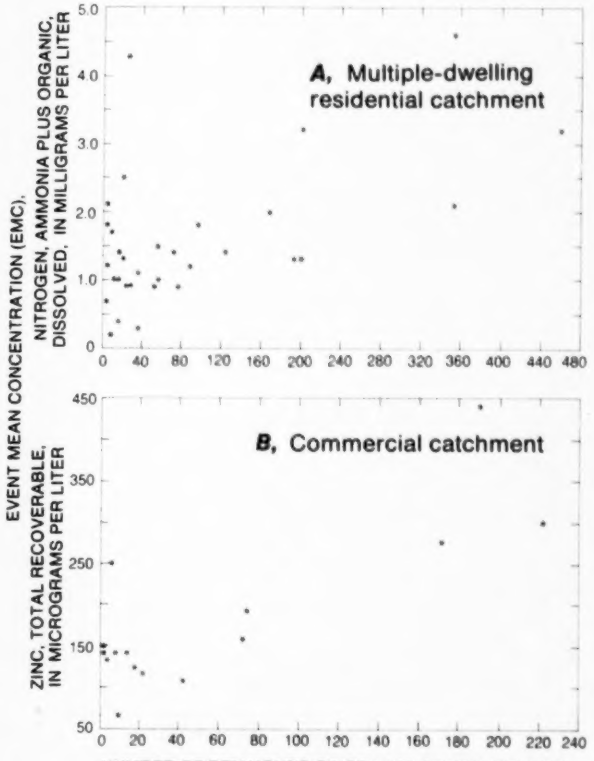


Figure 19. Comparison of constituent event mean concentrations and number of dry hours since last storm. *A*, Multiple-dwelling residential catchment. *B*, Commercial catchment.

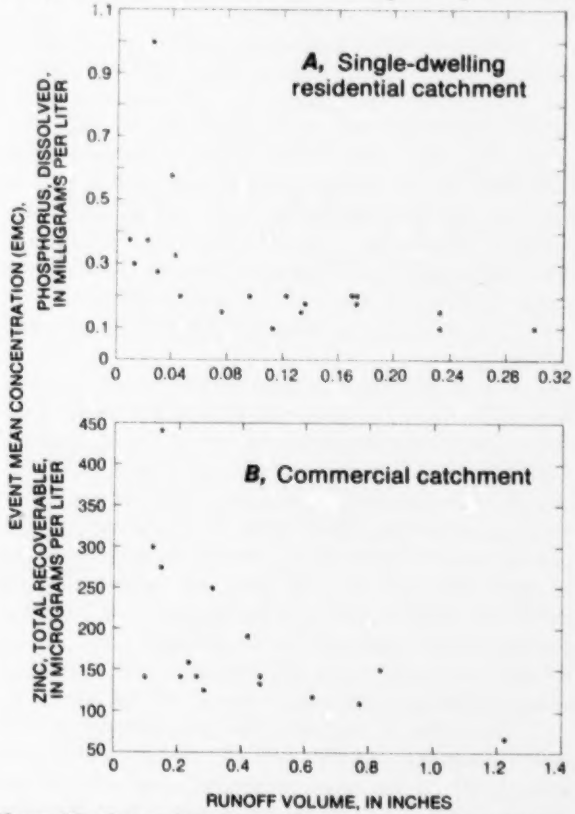


Figure 20. Comparison of constituent event mean concentrations and runoff volume. *A*, Single-dwelling residential catchment. *B*, Commercial catchment.

variables which affect constituent EMC's for which data are not available and, therefore, were not included in the analysis.

If regression analysis did not produce useful results, the mean EMC would have to be used to estimate the EMC. A statistical summary, including means of the EMC data shown in tables 18 to 21, is shown in table 24. The maximum EMC for the study period also is shown in table 24. The calculation of the mean excludes the early season high EMC's as also was done before regression analysis.

Because of the unusually high rainfall total during the second rain season, the calculated mean EMC's for some constituents and for some catchments probably are lower than the normal constituent EMC. The low mean EMC is due to the greater degree of dilution associated with the larger runoff volumes during the second rain season as previously discussed.

Inspection of the calculated EMC's for the second rain season for the commercial catchment indicates substantial increases in the EMC of suspended sediment, and total recoverable lead, iron, and nickel compared to the EMC for the first rain season. These increases probably are due to the adjacent construction activity and, therefore, were not included in the statistical summary.

Estimation of Land-Use Mean Annual Constituent Unit Loads

Estimates of mean annual constituent unit loads (pounds per acre) for each land-use catchment were calculated using the mean annual Fresno rainfall, mean rainfall-runoff coefficient, and mean constituent event mean concentrations (EMC's). Constituent unit loads were estimated for the 18 constituents that had calculated storm loads (tables 18 to 21). The estimated mean annual constituent unit loads for each catchment are shown in table 25.

Unit load estimates were computed by multiplying the mean rainfall-runoff coefficient for each catchment (table 5) by the mean annual rainfall of 10.24 inches to produce the average annual catchment runoff. The mean annual catchment runoff was multiplied by the mean of the constituent EMC's listed in table 24 with the resultant product divided by the catchment drainage area to produce the constituent unit load.

In deriving these estimates, no attempt was made to eliminate the bias of the rainfall-runoff coefficient and EMC data caused by the extreme high rainfall total during the second rain season. The two biases were assumed to cancel each other, and that any residual effect would not significantly affect the estimates.

The rainfall-runoff coefficient data for the second rain season has a positive bias because the coefficient tends to increase with increased quantities of rainfall. This increase is due to a larger quantity of rainfall draining off the catchment after the soils become saturated and the depression areas become full. Therefore, as shown by the data in table 4, the larger a storm, the higher the rainfall-runoff coefficient.

As previously discussed, the mean EMC data shown in table 24 probably has a negative bias. This bias is due to the greater degree of constituent dilution associated with larger runoff volumes.

It must be emphasized that transfer of these land-use constituent unit load estimates to other catchments outside and even within the Fresno area must be done with extreme caution. The monitored catchments are assumed to be representative land-use catchments for the Fresno area; however, this has not been verified. Also, data are not available from a similar land-use catchment in Fresno that could be used for comparing data variability between similar land-use catchments.

Even though most constituent concentrations for the industrial catchment are substantially higher compared to the commercial catchment, the data in table 25 shows that most unit loads for the two catchments are similar. This is due to the large difference in runoff volume from the two catchments. Phosphorus was the only constituent that had a unit load at one catchment substantially different from the other three catchments; the industrial catchment unit load is about 10 times higher than for the other catchments.

Dry-Weather Runoff Samples

During the months of August and September 1982, stage records of dry-weather runoff were periodically collected at the two residential sites in an attempt to estimate the volume of runoff during the summer months. The record for the multiple-dwelling residential catchment was fairly consistent from day to day because of the runoff from early morning lawn watering by automatic sprinkler systems. The data for the single-dwelling residential catchment were more sporadic with respect to flow periods. Based on the periodic stage records, the monthly dry-weather runoff volume for each of the residential catchments was estimated to be about 1 percent of the total annual runoff volume.

On September 3, 1982, grab samples of dry-weather runoff were collected at each of the two residential sites. The samples were sent to the laboratory for analysis of the constituents shown in table 2. The laboratory results were compared with the mean constituent concentrations of the discrete runoff samples shown in tables 13 and 14. The comparison showed that the dry-weather nutrient concentrations were all less, except for nitrate and nitrite plus nitrate, than the mean storm-runoff concentrations for the multiple-dwelling residential catchment. This also was true for the results of the single-dwelling residential dry-weather nutrient concentration, except for all the phosphorus species, which had concentrations two to three times higher than the mean storm-runoff concentrations.

Dry-weather metal concentrations for both catchments generally were less than the mean storm-runoff concentrations, except for arsenic which were about double.

All dry-weather major-ion concentrations for both catchments were about four to five times higher than the mean storm-runoff major-ion concentrations. This probably is because the dry-weather runoff water is predominantly municipal supply water taken directly from the aquifer underlying Fresno.

Only two pesticides, diazinon and malathion, had substantially higher dry-weather concentrations compared to the mean storm-runoff concentrations. The diazinon dry-weather concentrations were about three times higher than the mean storm-runoff concentrations, and malathion concentrations were about double. Both pesticides commonly are used by homeowners.

Atmospheric Dry-Deposition Quality Samples

Atmospheric dry-deposition samples were collected on an approximate 60-day interval from November 25, 1981, through April 19, 1983, at one site in the industrial and single-dwelling residential catchments. A statistical summary of these samples for each of the two sites is presented in tables 26 and 27.

Dry-deposition data are quite variable. Experience has shown that the amount of material collected in a dry-deposition collector bucket is highly affected by the location of the bucket with respect to the ground and street, wind conditions, and the activity in the surrounding area. The two deposition collectors used in this study were mounted in similar positions about 10 feet above the ground on the roof of the studies' instrumentation shelters and about 30 to 40 feet from light traffic-density streets. This similar positioning decreases some of the data collection variability between sites, but the collected data are unlikely to represent dry deposition over the entire catchment; therefore, catchment dry-deposition loads were not computed. Because of the variability of dry-deposition data, the following discussion will be more of a qualitative nature than quantitative even though quantitative numbers will be used.

The conventional reporting units for dry-deposition data are mass-concentration units (tables 26 and 27). Interpretation of the data using these units can be misleading. Plots of total recoverable lead from dry deposition in mass-concentration units compared to time for the two sites are shown in figure 21. The plots show the highest lead concentrations occurring during the first few months of the rain season with the lowest concentrations occurring during the spring months. The other plot shown on the figure is the deposition rate for the sample collection period of the total dry-deposition material collected. These plots show the total dry-deposition rate to be higher during the dry-weather periods than during the wet-weather periods. They also show that the total dry-deposition rate plots are completely out of phase from the mass-concentration plots. A lead deposition rate was calculated for each sample. The results showed a mean deposition rate range of 1.3 to 3.3 μg/d for the industrial site and 2.1 to 4.8 μg/d for the single-dwelling residential site. These small ranges indicate that the lead deposition rate is fairly uniform throughout the year. Therefore, the lead mass-concentration data and all other constituent mass-concentration data are significantly affected by the bulk dry-mass deposition rate at the sampling location.

It is noteworthy that the lead mass-concentration plots for the two sites show the same cyclic pattern as did plots of other constituent mass concentrations with time (fig. 22). This cyclic pattern implies that the deposition rate of most of the constituents also is fairly uniform throughout the year. The consistency of the plots for the two sites indicate that the patterns of dry deposition at the two sites are quite similar.

Street-Surface Particulate Quality Samples

Street-surface particulate samples were collected using a stainless steel canister shop vacuum and a random stratified data collection network (Oltmann and others, 1987) for each of the four catchments. The initial intent of collecting the samples was to define a catchment particulate buildup curve, and to determine which constituents at what concentrations are present on the street surfaces. It became evident very early that the definition of a particulate buildup curve was not possible because of the inaccuracies of data collection. For example, the 20 to 25 curb-to-curb samples (Oltmann and others, 1987) collected for each catchment and composited for laboratory analysis represents only about 0.1 percent of the catchment street-surface area. The multiple-dwelling residential and industrial catchments often had small sand and silt deposits in the gutters because of erosion from adjacent slopes. If the vacuum got too close to these deposits, the large amount of material which could be inadvertently collected compared to the amount collected from the other curb-to-curb samples could bias the sample. Because of these types of errors, no street-surface particulate loads will be computed. A statistical summary by catchment of the laboratory constituent concentration data for the analyzed samples is presented in tables 28 through 31.

The high constituent concentrations for some of the metals and organic constituents obtained at the commercial catchment probably are a result of the parking lot being commercially swept daily. The sweeper removes the large gravel-size material, but is unable to remove all the fine-grained material. There is a greater percentage of particulate surface area per volume of material for fine-grained material compared to large-grained material. Metals and organics tend to adsorb to the surface of fine-grained particulate material; therefore, the constituent mass concentration values for the commercial catchment are considerably higher than for the other three catchments. These data do not signify, however, that the surface of the commercial catchment contains larger amounts of constituents than the surface of the other three catchments.

Comparison of Rainfall and Runoff Quality Data

Constituent rainfall loads (tables 10 and 11) and runoff loads (tables 18 to 20) for the industrial, single-dwelling residential, and multiple-dwelling residential catchments were combined into one data set to investigate the relation between catchment constituent rainfall and runoff loads. Rainfall quality data are available only at the industrial and single-dwelling residential sites, but because the single-dwelling

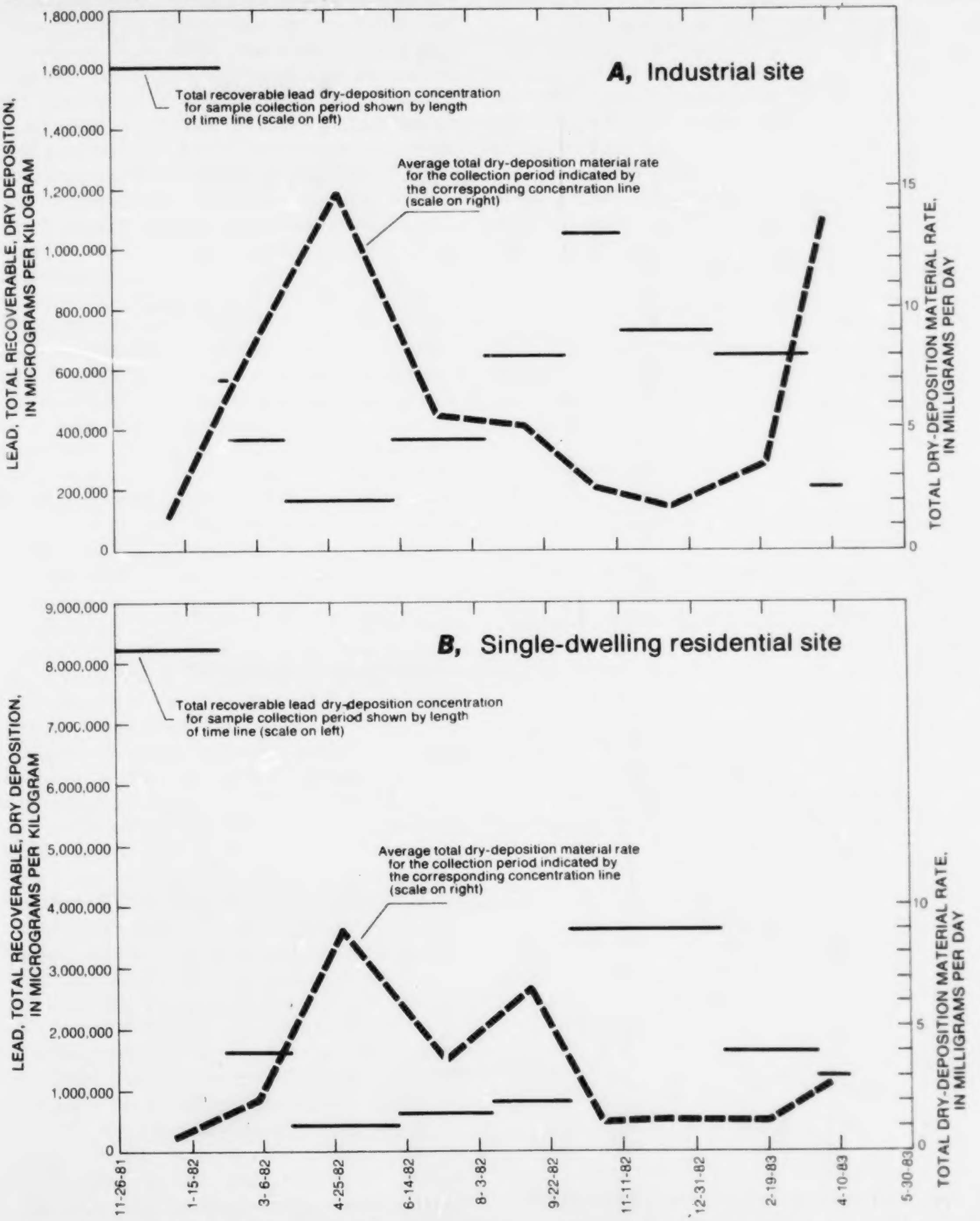


Figure 21. Comparison of total recoverable lead for atmospheric dry deposition and total dry-deposition material rate with time. *A*, Industrial site. *B*, Single-dwelling residential site.

residential and multiple-dwelling residential catchments are less than 0.75 mile apart, the rainfall quality data collected at the single-dwelling residential site are assumed representative of the rainfall quality for the multiple-dwelling residential catchment. Rainfall quality data for the single-dwelling residential site were not used for the commercial catchment because the catchments are 2 miles apart, and the rainfall quality data may not be transferable for that distance.

The comparison between rainfall loads and runoff loads was done assuming that the rainfall load constituents would

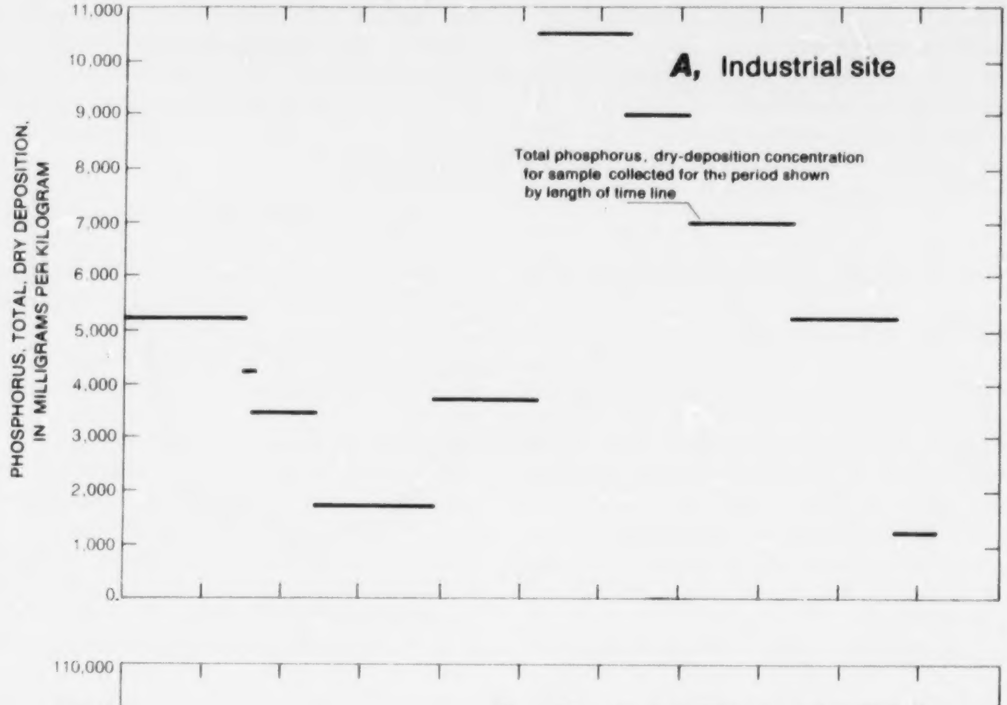


Figure 22. Comparison of constituent atmospheric dry-deposition concentrations with time. *A*, Industrial site. *B*, Single-dwelling residential site.

not be altered in any way during runoff. The rainfall loads shown in tables 10 and 11 represent the total amount (in pounds) of a constituent that landed on the catchment for that particular storm. In order to compare these loads with runoff loads, the rainfall load was multiplied by the rainfall-runoff coefficient (table 4) for that particular storm to provide that part of the rainfall load which drained off the catchment. These rainfall drainoff loads and runoff loads for selected constituents for the industrial and two residential catchments, and the percentage of the runoff constituent load attributable to rainfall are shown in table 32. The rainfall loads of the multiple-dwelling residential catchments were determined by adjusting the rainfall loads for the single-dwelling residential catchment (table 11) based on drainage area difference before multiplying by the rainfall-runoff coefficient. Rainfall constituents for which most of the concentrations were less than the analytical detection limit were not used. Because of the high degree of unexplained variability in the percentage rainfall load data and the small number of observations, the median value was chosen for comparison purposes.

Comparing the median percentage rainfall-load data for organic nitrogen plus ammonia and nitrite plus nitrate indicate that the two residential catchments are similar. Both show that a high percentage of the runoff load for these two constituents is attributable to rainfall (single-dwelling residential, 47 and 42 percent, respectively; multiple-dwelling residential, 56 and 44 percent, respectively). The median percentage rainfall load for the industrial catchment for these two constituents showed much lower values (10 and 25 percent, respectively) compared to the two residential catchments. Because a statistical difference was not found between the rainfall quality data for the industrial and single-dwelling residential sites for nitrite plus nitrate (table 9), the rainfall loads also should be equivalent. Therefore, the lower percentages are due to the higher nitrite plus nitrate runoff loads for the industrial catchment compared to the residential catchments. Ammonia plus organic nitrogen was statistically different in rainfall between sites (table 9). However, the runoff load for the industrial catchment is about five times larger than for the single-dwelling residential catchment (table 25), which explains the large difference in percentage of runoff load attributable to rainfall. Phosphorus shows the same relation between catchments as the nitrogen species, however, the rainfall percentages are all 10 percent or less.

The remaining constituent data shown in table 32 also show that the rainfall load contribution is smaller for the industrial catchment than the residential catchments, except for total recoverable lead. This reversal of the trend is because lead is one of the few constituents that has lower runoff concentrations for the industrial catchment compared to the residential catchments (table 24). The difference between constituent median rainfall percentage for the two residential catchments is due to the variation in the constituent runoff loads at the two catchments. For example, the multiple-dwelling residential catchment event mean concentration (EMC) for total recoverable iron (table 24) is almost three times higher than for the single-dwelling residential catchment. Therefore, the median rainfall percentage for the multiple-dwelling residential catchment is about one-third that of the single-dwelling residential catchment.

The difference between the rainfall drainoff load and the storm-runoff load represents the load attributable to catchment washoff. Some of the sources that contribute to this washoff load consist of atmospheric dry deposition, vehicular deposition, animal waste, fertilizers, and overland flow of erosion material.

Average ion concentrations in milliequivalents per liter for all sampled storms during the study at the three rainfall sampling sites are shown in a pie diagram (fig. 23). When comparing this diagram with those shown for runoff in figure 10, it is evident that the rainfall composition is quite different from the composition of runoff from the industrial catchment, but similar to the other three land-use sites. The effects of basin washoff on ionic composition is much greater for the industrial catchment than any of the other three catchments and is indicative of the land-use characteristics in the industrial catchment.

Pesticides

Because Fresno is in the highly agricultural San Joaquin Valley, pesticides commonly used in the area were analyzed for in runoff from each catchment, rainfall, atmospheric dry-deposition, and street-surface particulates. For catchment runoff, discrete grab samples were collected during storms to avoid contamination by the organic-based components of the automatic sampling equipment. Precipitation

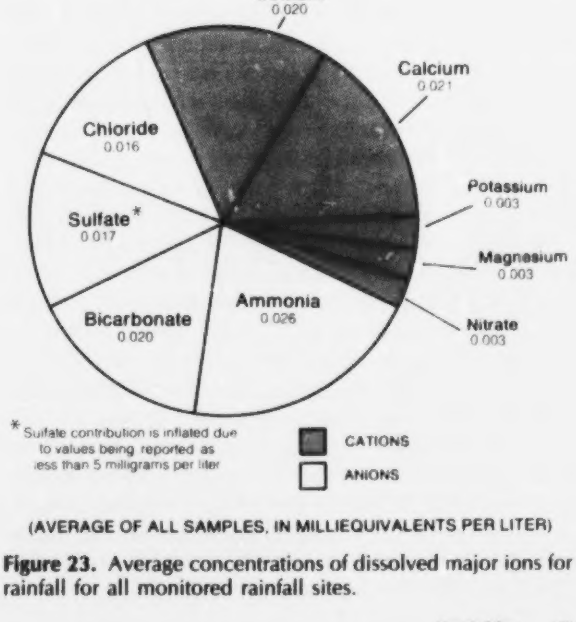


Figure 23. Average concentrations of dissolved major ions for rainfall for all monitored rainfall sites.

and dry-deposition samples were collected using metal and glass samplers that were placed in position by hand before and after storms. Dry-deposition samples were difficult to collect because of trace amounts of precipitation that would unexpectedly occur, washing the sample off the collector. Automatic wetfall/dryfall collectors were not used for the same reasons mentioned above for catchment-runoff samples. Street-surface particulate samples were collected using a high-powered stainless steel vacuum at selected locations in each basin. A detailed discussion of collection methods is in Oltmann and others (1987).

The pesticides analyzed during the study for each of the four data types are shown in table 33. Not all the pesticides in the list were analyzed for each data type (rainfall, runoff, dry deposition, and street particulate). A statistical summary of pesticides identified in samples from all three of the rainfall monitoring sites is shown in table 34. Comparisons between these sites showed no statistically significant difference ($\alpha=0.05$) for any of these pesticides. See page 13 for a discussion of the statistical techniques used.

Results from the laboratory monitoring site are not used in the following discussion because data were collected only during the second year to verify results at the other two sites. The organophosphorus compounds, parathion, malathion, and diazinon, were the most prevalent in the rainfall during the study period. The occurrences of parathion and diazinon were shown to be correlated ($R=0.71$) using PROC CORR of SAS (Helwig and Council, 1979). These two insecticides are used in the San Joaquin Valley primarily as dormant sprays on fruit trees, which probably accounts for their occurrence in the rain. The most common application method used is a high-volume, truck-mounted sprayer that tends to suspend large quantities of spray into the air, facilitating movement by wind currents. Some diazinon was detected in the early season storms in September, October, and November (fig. 24), but parathion did not become evident until the late December and January storms (fig. 24). Both compounds were detected throughout the remainder of the rain season. The concentrations observed seem to be dependent on the storm rainfall total and the length of time since the last storm. Concentrations generally were higher during the first year, but loadings generally were higher during the second year due to the higher storm rainfall totals. An example of this can be seen for parathion in figure 25. Malathion, whose usage has decreased in recent years, occurred in low concentrations during the study, and its occurrence was more variable than either parathion or diazinon (fig. 26).

The organochlorine insecticides and the chlorophenoxy acid herbicide, 2,4-D, were not detected as often or in as large a concentration as parathion or diazinon. Insecticides in the organochlorine group and 2,4-D are applied primarily by aircraft in the San Joaquin Valley. Organochlorine insecticides have been reported in rainfall in previous studies including Bevenue and others (1972), Eisenreich and others (1981), and Strachan and Huneault (1979). Most of the occurrences in this study were during the first year when there was considerably less rainfall than during the second year. Chlordane was detected during the first sampled storm of the study and once subsequent to that at the industrial site. The rest of the time it was at or less than the detection limit of 0.10 μg/L (fig. 27). Methoxychlor was greater than the detection limit only during March of both years (fig. 27). Endosulfan was detected during March of both years and at the single-dwelling residential site in October of the second year (fig. 27). Lindane was detected only once at the single-dwelling residential site and seven times at the industrial site, five of those times coming during the first year of the study (fig. 27). The chlorophenoxy acid herbicide, 2,4-D, was detected during January to March of both years (fig. 28).

Of the eight pesticides detected in the rain, only parathion, diazinon, malathion, chlordane, lindane, and 2,4-D occurred regularly in the catchment runoff grab samples. A statistical summary of the six pesticides in runoff is shown in table 35. All other pesticides detected in runoff occurred very infrequently in each of the four catchments. Chlordane occurred more frequently in the catchment runoff than it did in the rainfall. The use of this product in urban areas to con-

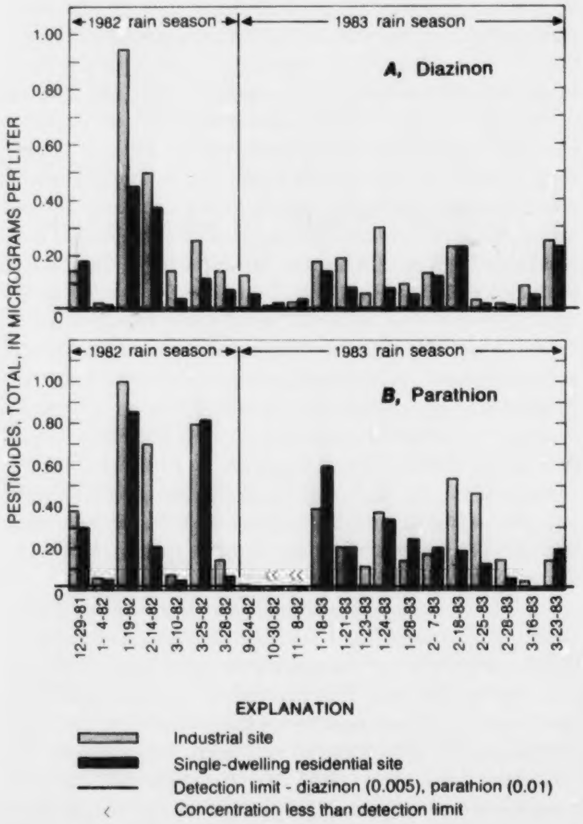


Figure 24. Diazinon and parathion concentrations in storm-composite rainfall samples collected at industrial and single-dwelling residential sites. *A*, Diazinon. *B*, Parathion.

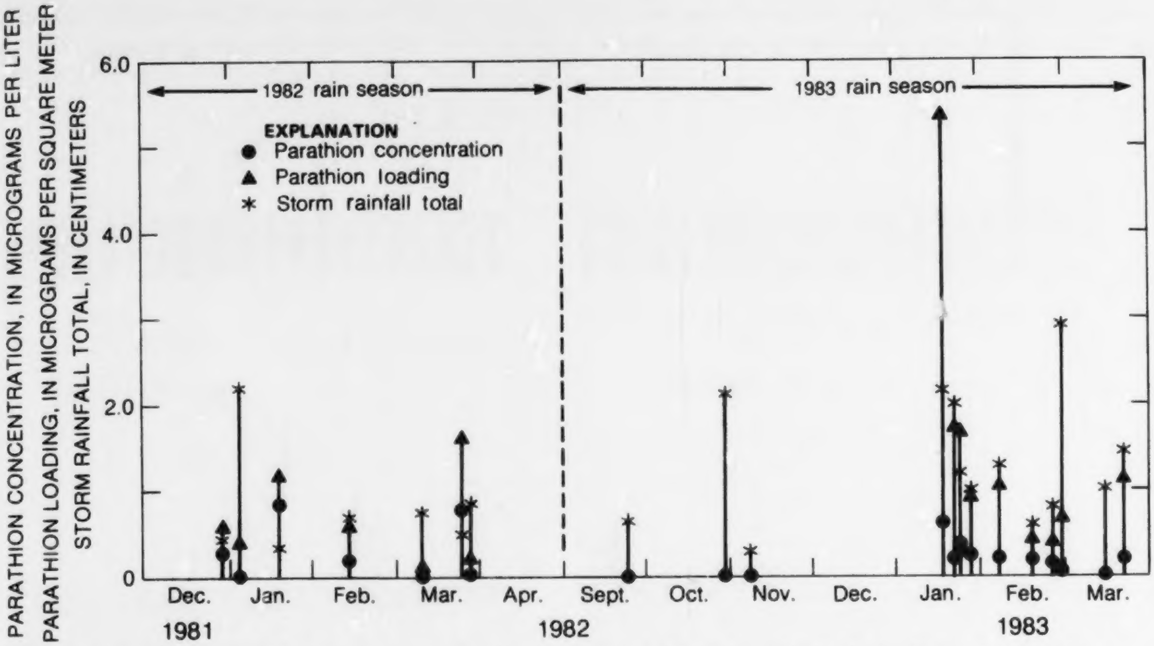


Figure 25. Parathion concentration, parathion loading, and storm rainfall totals at the single-dwelling residential site.

trol ants and termites may be the reason that its occurrence is more frequent in runoff. Diazinon and malathion are readily available products for use in yards and gardens in urban areas as well as being used extensively in agriculture. Both of these occurred as frequently in runoff from all four catchments as they did in the rain. Parathion also occurred frequently in runoff from each catchment. Because of its primarily commercial agricultural uses and high concentrations in the rainfall, it probably is being imported into the urban area from surrounding agricultural areas. Lindane is used in residential and structural pest control. The herbicide 2,4-D is used commercially in the surrounding agricultural communities.

The only pesticide that seems to correlate with land use is chlordane. The single-dwelling residential, multiple-dwelling residential, and commercial catchments all had more frequent occurrences of chlordane than did the industrial catchment.

All of the pesticides detected in atmospheric dry deposition also were detected in catchment runoff and rainfall (table 33). In addition, most pesticides detected in the street-surface particulate samples were detected in the catchment runoff (table 33). A complete listing of all pesticide data are given in Oltmann and others (1987).

COMPARISON WITH WATER-QUALITY CRITERIA AND STANDARDS

The city of Fresno gets its drinking water from ground water that is in part recharged by urban runoff collected in recharge basins. Because of this, there is interest in how the quality of the urban runoff compares with drinking water standards. Water that exceeds specific criteria prior to recharge will not necessarily pose problems to the ground-water supply, but may require close monitoring. Schematic plots and criteria values of constituents for which there are drinking water regulations established by the U.S.

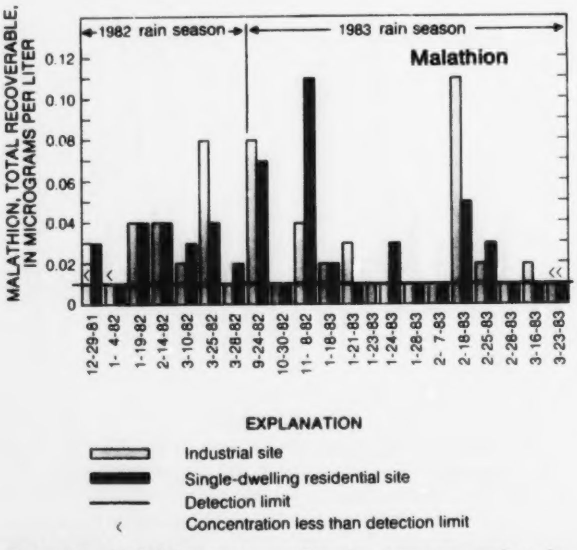


Figure 26. Malathion concentrations in storm-composite rainfall samples collected at industrial and single-dwelling residential sites.

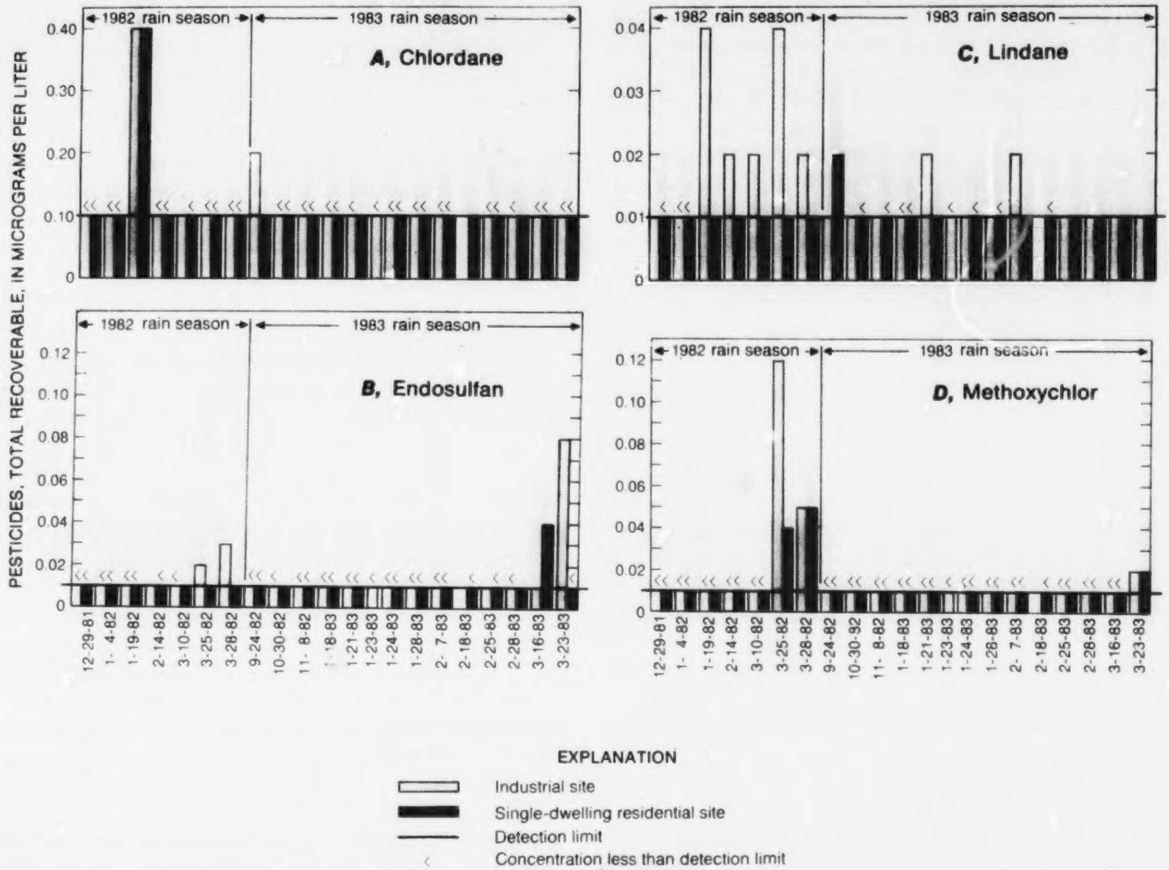


Figure 27. Organochlorine insecticide concentrations in storm-composite rainfall samples collected at industrial and single-dwelling residential sites. *A*, Chlordane. *B*, Endosulfan. *C*, Lindane. *D*, Methoxychlor.

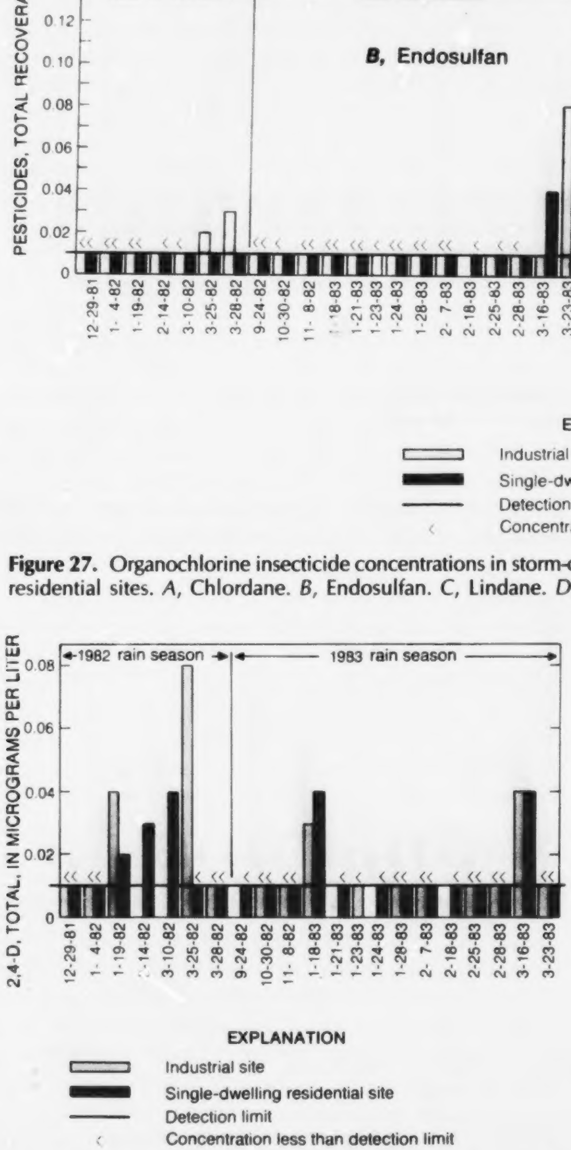


Figure 28. 2,4-D concentration in storm-composite rainfall samples collected at industrial and single-dwelling residential sites.

Environmental Protection Agency (1977, 1979) in the Safe Drinking Water Act, Title 40, parts 141 (primary) and 143 (secondary) are shown in figures 29 and 30. Mandatory limits in the Safe Drinking Water Act are referred to as primary drinking water regulations (fig. 29), and the recommended limits are referred to as secondary drinking water regulations (fig. 30).

SUMMARY

The Fresno Metropolitan Flood Control District (FMFCD) has routed urban stormwater runoff to local man-made retention basins since 1956. These 10- to 15-acre basins allow the runoff water to percolate through the underlying soil where it recharges the aquifer that underlies the city of Fresno. The aquifer is the source of the city's domestic water supply and has been designated as a "Sole-Source Aquifer" by the U.S. Environmental Protection Agency (EPA).

FMFCD received a grant from EPA under the National Urban Runoff Project (NURP) to investigate the potential environmental effects associated with recharge of urban stormwater runoff. FMFCD requested the U.S. Geological Survey to characterize stormwater runoff from four different land-use catchments and requested the U.S. Department of Agriculture in Fresno to investigate the effects of stormwater runoff and its constituents on the ground-water supply and local soils.

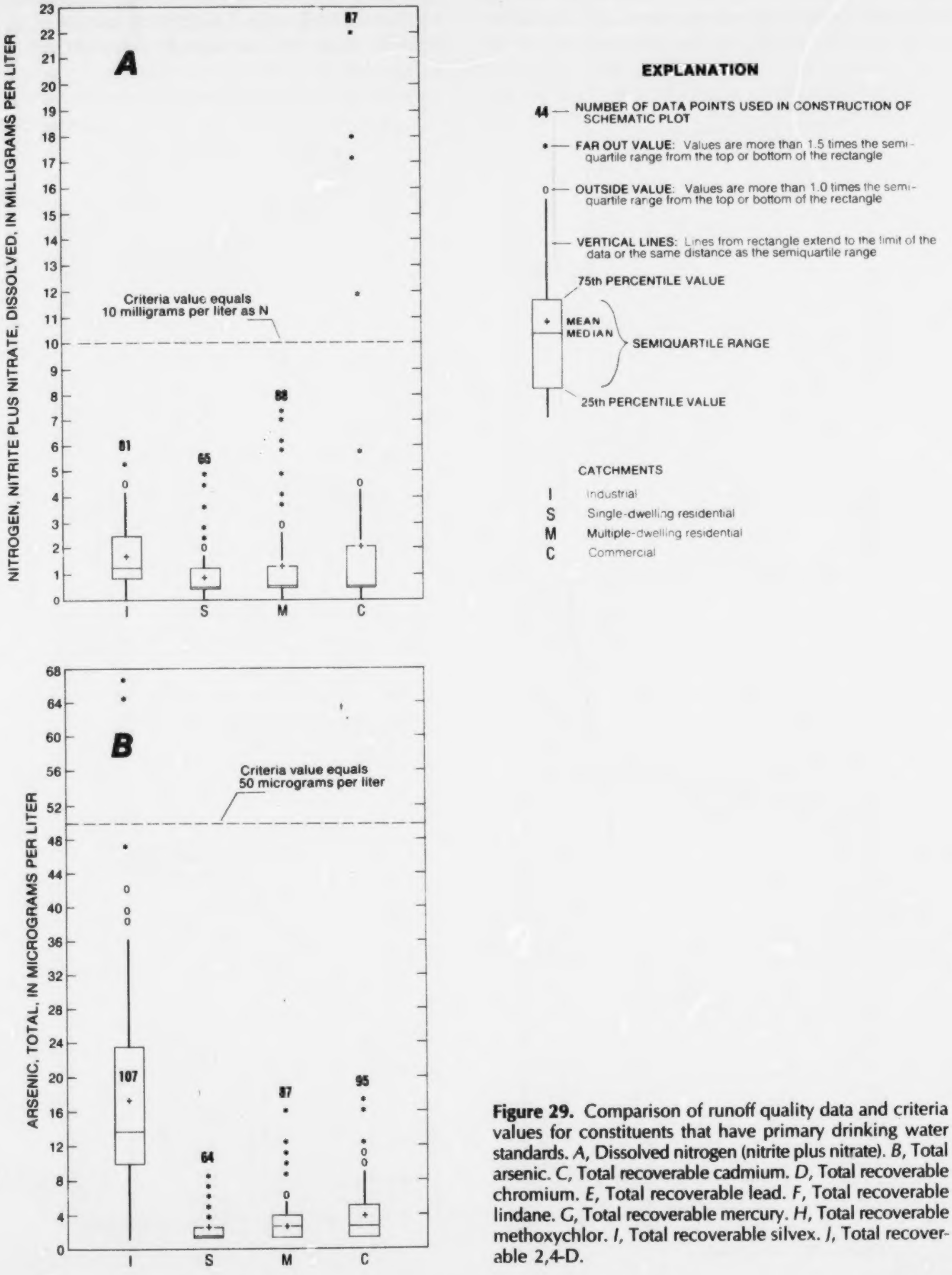


Figure 29. Comparison of runoff quality data and criteria values for constituents that have primary drinking water standards. *A*, Dissolved nitrogen (nitrite plus nitrate). *B*, Total arsenic. *C*, Total recoverable cadmium. *D*, Total recoverable chromium. *E*, Total recoverable lead. *F*, Total recoverable lindane. *G*, Total recoverable mercury. *H*, Total recoverable methoxychlor. *I*, Total recoverable silvex. *J*, Total recoverable 2,4-D.

Rainfall and runoff quantity and quality from an industrial, single-dwelling residential, multiple-dwelling residential, and commercial land-use catchment were monitored during the 1981–82 and 1982–83 rain seasons. Discrete runoff samples were collected throughout storms in addition to storm composite rainfall samples, and were analyzed for numerous physical, inorganic, organic, and biological constituents. Atmospheric dry-deposition and street-surface particulate samples were collected and analyzed.

Storm characteristics data were calculated and compiled for the two rain seasons. Rainfall total, number of dry hours since last storm, and maximum 20-minute rainfall intensity

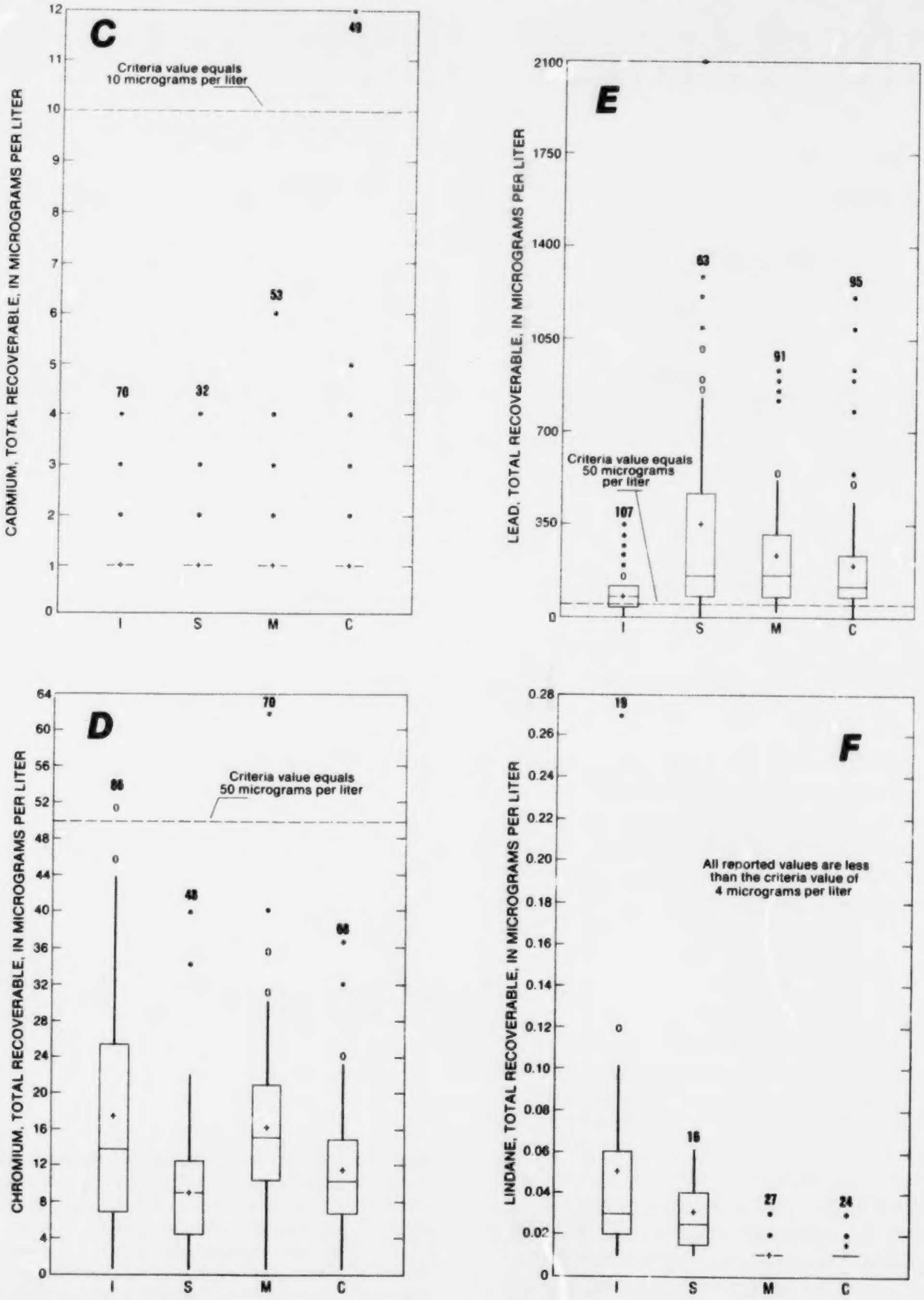


Figure 29. Continued.

were used as independent variables to develop rainfall-runoff multiple regression equations for all four catchments. Rainfall total was the only statistically significant independent variable at the 0.05-significance level for the commercial catchment. All three variables were significant for the multiple-dwelling residential catchment. Rainfall total and number of dry hours since last storm were the only significant variables for the single-dwelling residential and industrial catchments.

Results of nonparametric statistical comparison testing showed there was no statistical difference at the 0.05-significance level for rainfall constituent concentrations between rain seasons at the single-dwelling residential site. At the industrial site, only dissolved phosphorus and dissolved organic carbon were statistically different between rain seasons. Results of comparison testing among rainfall sites showed significantly higher concentrations of ammonia plus organic nitrogen, ammonia, pH, and phenols in rain-

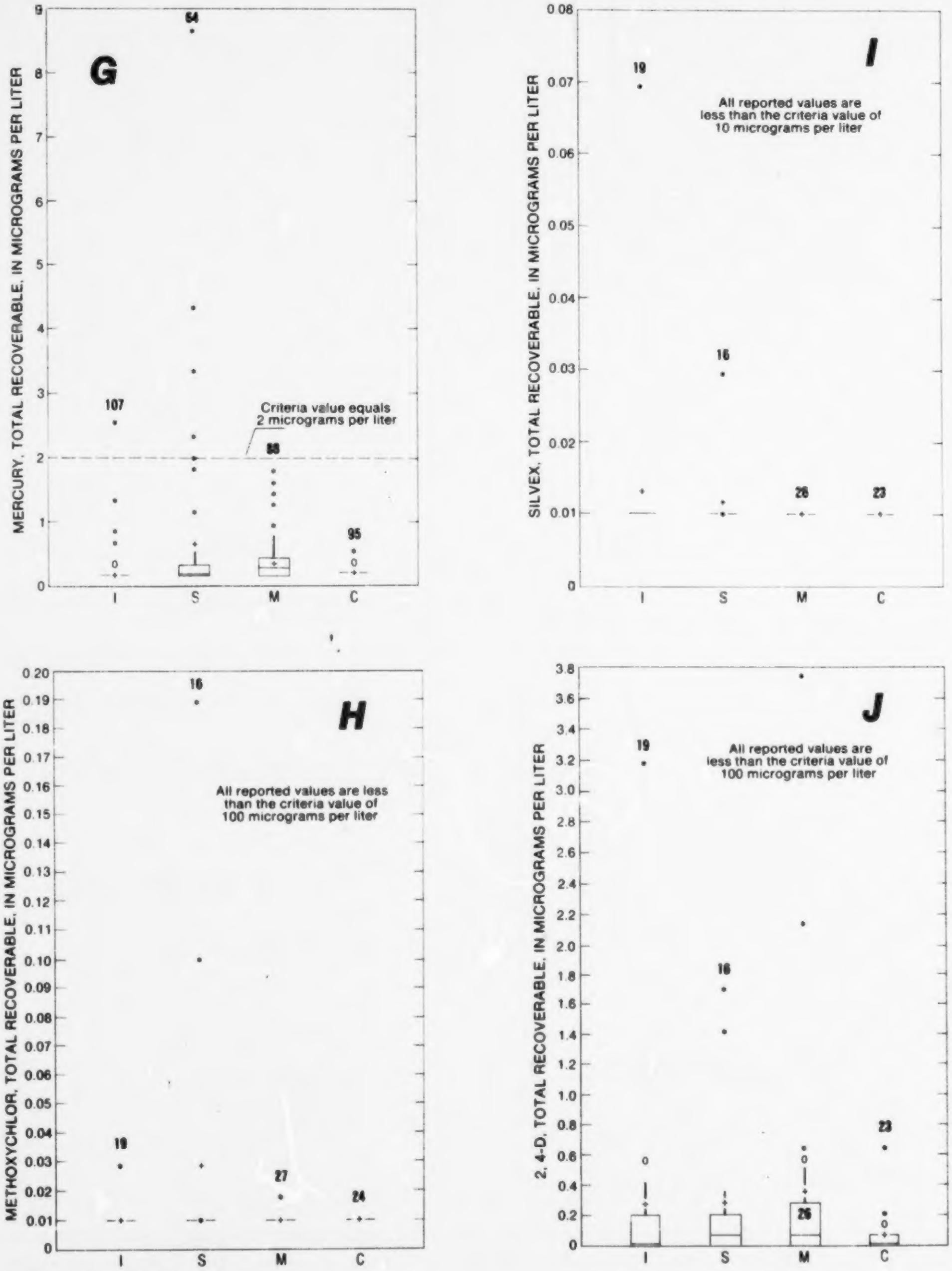


Figure 29. Continued.

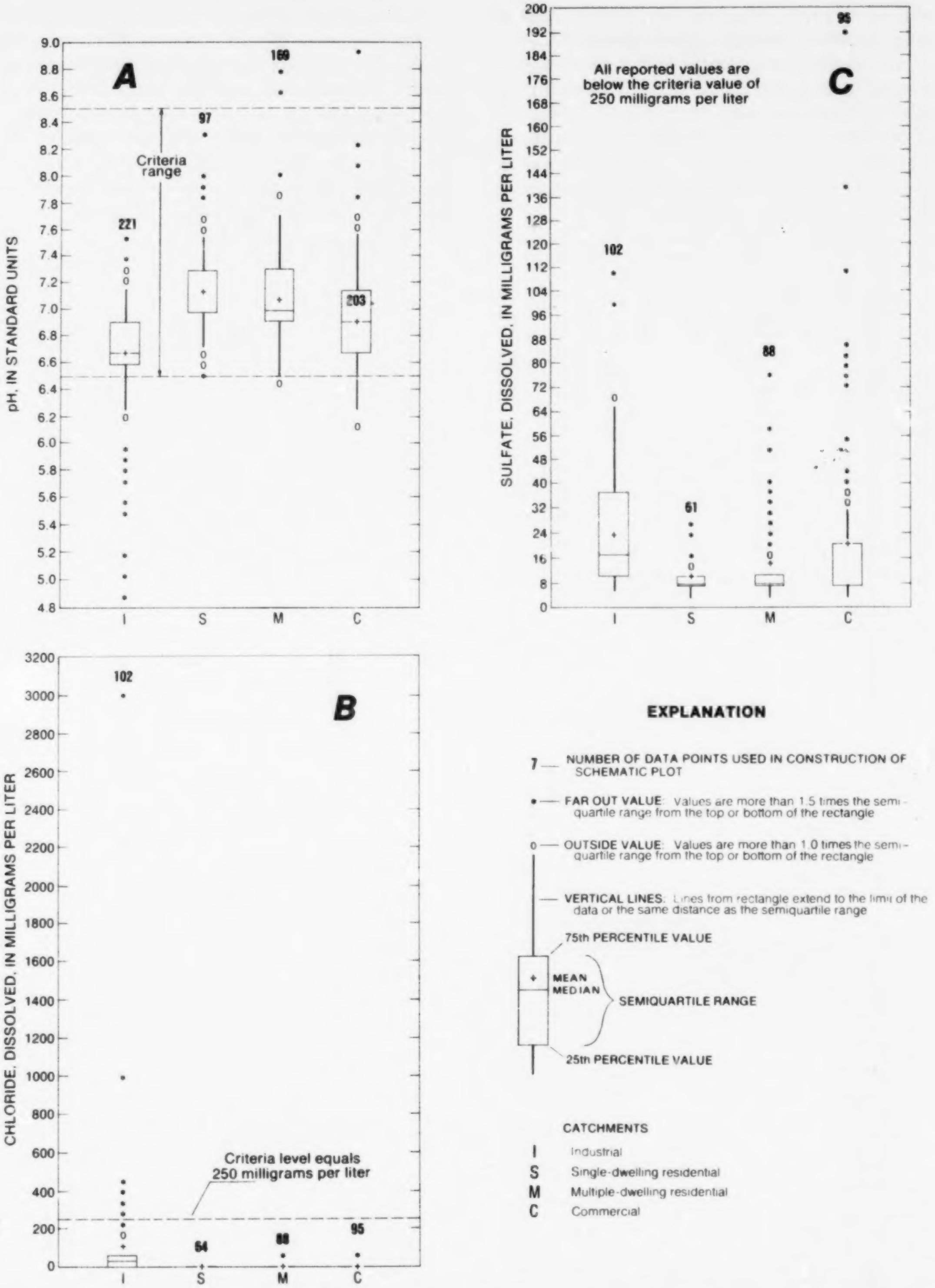


Figure 30. Comparison of runoff quality data and criteria values for constituents that have secondary drinking water standards. *A*, pH. *B*, Dissolved chloride. *C*, Dissolved sulfate. *D*, Total recoverable copper. *E*, Total recoverable iron. *F*, Total recoverable manganese. *G*, Total recoverable zinc.

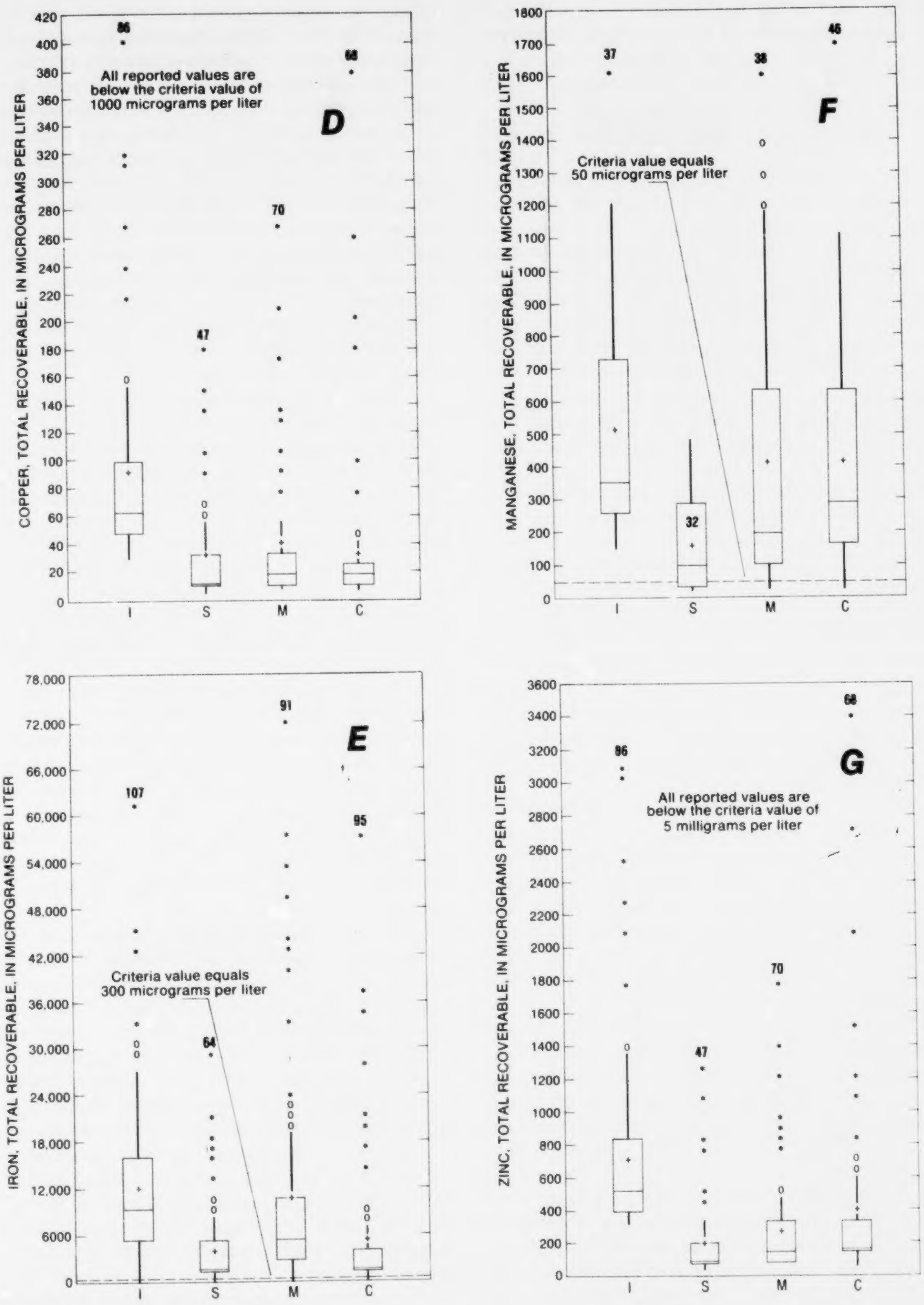


Figure 30. Continued.

fall at the industrial site than for the two residential sites.

The highest runoff concentrations for most constituents from the residential and commercial catchments occurred during the initial storm runoff and then decreased throughout the remainder of the storm, independent of hydraulic conditions. Metal concentrations generally were higher during initial runoff, but also increased as flow increased. Most runoff constituent concentrations from the industrial catchment fluctuated greatly during storms; numerous unexplained concentration spikes were monitored.

Results of nonparametric statistical comparison testing of runoff constituent data showed significantly higher concentrations for the industrial catchment compared to the residential and commercial catchments for almost all 62 monitored nonpesticide constituents. Of the 62 monitored constituents, only 10 were determined to have comparable concentrations between the industrial catchment and at least one of the other three catchments. Total recoverable lead was one of the very few constituents that had lower concentrations for the industrial catchment compared to the other three catchments. Sodium and pH were the only constituents that had significantly different concentrations for all four catchments. For the two residential catchments, 50 of the 57 monitored constituents were determined to have statistically equivalent runoff concentrations. Of the 12 constituents determined to be significantly different, the higher suspended sediment, iron, aluminum, and manganese concentrations for the multiple-dwelling residential catchment probably are the result of soil erosion from undeveloped land areas and, therefore, are not really representative of urban runoff. The commercial catchment runoff concentrations for most constituents generally were similar to concentrations for the residential catchments.

Numerous constituent concentration relations were developed for all but the industrial catchment using linear regression analysis. The most noteworthy relations were those between specific conductance and dissolved organic nitrogen plus ammonia, dissolved nitrite plus nitrate, and dissolved phosphorus. The lowest "percentage of variation explained" for these nine relations was 86 percent. These equations were used to estimate concentrations that were then used to compute storm constituent loads.

Constituent event mean concentrations (EMC's) were calculated from computed storm-runoff loads. The EMC for most constituents for all but the industrial catchment were highest for the first two or three storms of the year after which they became quasi-constant for the remainder of the rain season. The industrial constituent EMC's generally did not show any pattern.

EMC multiple regression predictor equations were developed for some constituents using number of dry hours since last storm, runoff volume, and number of days since first storm of rain season as independent variables. Number of dry hours since last storm and runoff volume were the predominant independent variables, which indicates that material accumulates on the catchment with time between storms, and that the EMC is dependent upon the volume of runoff that washes off and dilutes the accumulated material.

Average annual constituent unit loads were computed for 18 constituents for each catchment using the average Fresno annual rainfall total, the average rainfall-runoff coefficient for each catchment, and the average constituent EMC's for each catchment. Although most constituent concentrations for the industrial catchment are substantially higher compared to the commercial catchment, the unit loads for the two catchments are similar because of the large difference in catchment runoff volume. Phosphorus is the only constituent that has a unit load for one catchment that is substantially different from the other three catchments; the industrial catchment unit load is about 10 times higher than that for the other catchments.

Forty to fifty percent of the nitrogen runoff loads for the two residential catchments were attributed to the rainfall load. In the case of phosphorus, 10 percent or less of the runoff load was attributable to rainfall. These percentages are considerably less for the industrial catchment because of the larger runoff nutrient loads for the industrial catchment compared to the residential catchments. The same can be said for other constituents, except for lead which is one of the very few constituents that had lower runoff concentrations for the industrial catchment compared to the residential catchments. Rainfall metal load percentages generally were smaller than for nutrients.

The difference between the rainfall load and the runoff load represents the load attributable to catchment washoff. Some of the sources that contribute to this washoff load consist of atmospheric dry deposition, vehicular deposition, animal waste, fertilizers, and overland flow erosion material. Because of the uncertainty of collecting atmospheric dry-deposition and street-surface particulate data, the samples collected of these types of data were not used to compute catchment loads for use in catchment pollutant budget analysis.

The conventional use of mass-concentration units for the reporting of atmospheric dry-deposition and street-surface particulate constituent concentrations can be misleading. Time-series plots of dry-deposition constituent concentrations show a cyclic pattern throughout the year. However, time-series plots of total dry-mass deposition rate also are cyclic, but totally out of phase from the concentration plots. This indicates that dry-deposition mass-concentration data are significantly affected by the bulk dry-mass deposition rate.

The street-surface particulate mass-concentration data for some of the metal and organic constituents for the commercial catchment are considerably higher than for the other three catchments. These higher concentrations are due to the removal of the large gravel-size material by a daily commercial sweeping service and are not indicative of larger amounts of these constituents on the surface of the commercial catchment compared to the other three catchments. The sweeper is unable to remove all the fine-grained material, which has a greater percentage of particulate surface area per volume of material compared to the coarse-grained material. Metal and organic constituents tend to adsorb to the surface of fine-grained particulate material, thus resulting in higher mass concentrations.

The organophosphorus compounds, parathion, diazinon, and malathion were the most prevalent pesticides detected in rainfall. Other detected pesticides in rainfall included chlordane, lindane, methoxychlor, endosulfan, and 2,4-D. Of these, only methoxychlor and endosulfan were not consistently detected in the runoff. Chlordane occurred more frequently in runoff than in rainfall. In addition, pesticides detected in atmospheric dry-deposition and street-surface particulate samples were detected in rainfall and runoff.

SELECTED REFERENCES

Bevenue, A., Ogata, J.N., and Hylin, J.W., 1972, Organochlorine pesticides in rainwater, Oahu, Hawaii, 1971-1972: Bulletin of Environmental Contamination and Toxicology, v. 8, no. 4, p. 238-241.

Doyle, W.H., Jr., and Lorens, J.A., 1982, Data management system for urban hydrology studies program: U.S. Geological Survey Open-File Report 82-442, 272 p.

Eisenreich, W.J., Looney, B.B., and Thornton, J.D., 1981, Airborne organic contaminants in the Great Lakes ecosystem: Environmental Science and Technology, v. 15, no. 1, p. 30-38.

Gibbs, R.J., 1977, Transport phases of transition metals in the Amazon and Yukon Rivers: Geological Society of America Bulletin, v. 88, p. 829-843.

Helwig, J.T., and Council, K.A., eds., 1979, SAS user's guide: SAS Institute, Inc., Raleigh, North Carolina, 494 p.

Hem, J.D., 1970, Study and interpretation of the chemical characteristics of natural water: U.S. Geological Survey Water-Supply Paper 1473, 363 p.

National Oceanic and Atmospheric Administration, 1981, Climatological data, annual summary, California, 1981: v. 85, no. 13.

Oltmann, R.N., Guay, J.R., and Shay, J.M., 1987, Rainfall and runoff quantity and quality data collected at four urban land-use catchments in Fresno, California: October 1981 to April 1983: U.S. Geological Survey Open-File Report 84-718, 139 p.

Strachan, W.M.J., and Huneault, H., 1979, Polychlorinated biphenyls and organochlorine pesticides in Great Lakes precipitation: Journal of Great Lakes Research, v. 5, no. 1, p. 61-68.

U.S. Environmental Protection Agency, 1977, National interim primary drinking water regulations: U.S. Environmental Protection Agency, Office of Water Supply, EPA 570/9-76-003, 159 p.

_____ 1979, National secondary drinking water regulations: Federal Register, v. 44, no. 140, July 19, 1979, p. 42195-42202.

Wershaw, R.L., Fishman, M.F., Grabbe, R.R., and Lowe, L.E., 1983, Methods for the determination of organic substances in water and fluvial sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 5, Chapter A3, 173 p.

TABLES 1–35

Table 1. Characteristics of the four monitored urban-runoff catchments

[., no data available]

Catchment characteristic	Catchment			
	Industrial	Single-dwelling residential	Multiple-dwelling residential	Commercial
Contributing drainage area (acres)	278	94.0	46.1	61.8
Impervious area (percentage of drainage area)	52.5	43.4	57.0	98.9
Average basin slope (ft/mi)	8.00	7.90	7.03	13.8
Main conveyance slope (ft/mi)	8.00	28.6	9.96	5.70
Permeability of a horizon of soil profile (inches/hour)	2.70	3.75	7.50	.
Soil-water capacity (inch of water/inch of soil)	0.12	0.12	0.07	.
Soil-water pH of the A horizon	6.7	6.7	6.7	.
Hydrologic soil group, SCS methodology[1]	B	B	A	.
Population density (person/mi^2)	0	7,700	16,400	0
Street density (lanes/mi^2)	16	47	39	11
Land use, percentage of drainage area:				
Low-density residential	0	9.0	0	0
Medium-density residential	0	87.3	0	0
High-density residential	0	0	87.0	0
Commercial	0	0	0	100.0
Industrial	65.8	0	0	0
Idle or vacant	34.2	3.7	13.0	0
Detention storage, within catchment associated with storage facilities (acre-feet of storage)	0	0	0	0
Percentage of area drained by storm-sewer system	100.0	100.0	100.0	100.0
Percentage of streets with curb and gutter drainage	47.0	100.0	96.3	100.0
Percentage of streets with ditch and swale drainage	53.0	0	3.7	0

---

[1] Soil Conservation Service (SCS) designations: A, soils having a high infiltration rate; B, soils having a moderate infiltration rate.

Table 2. Quality constituents analyzed for in rainfall, runoff, atmospheric dry-deposition, and street-surface particulate samples

[Type of sample: x, analyzed for during both rain seasons; 1, analyzed for during 1981-82 rain season only; 2, analyzed for during 1982-83 rain season only; 3, analyzed for September 3, 1982; ., no data available. Atmospheric dry deposition: Material was washed from a collection bucket with deionized water and then analyzed as a water sample. Street-surface particulate: All constituents are total recoverable from dry samples. Atmospheric dry-deposition and street-surface particulate samples are reported in mass concentration units]

Property or constituent	Type of sample				
	Rainfall	Runoff	Atmospheric dry deposition	Street-surface particulate	Dry-weather runoff
INORGANICS					
Specific conductance	x	x	.	.	3
pH	x	x	.	.	3
Major ions					
*Hardness, total (as CaCO$_3$)	.	x	.	.	3
Calcium, dissolved	x	x	x	x	3
Magnesium, dissolved	x	x	x	x	3
Sodium, dissolved	x	x	x	x	3
Potassium, dissolved	x	x	x	x	3
Alkalinity, total (as CaCO$_3$)	x	x	.	.	3
Sulfate, dissolved	x	x	x	.	3
Chloride, dissolved	x	x	x	.	3
Silica, dissolved	x	x	x	.	3
Nutrients					
Nitrogen, nitrate, dissolved (as N)	.	1	.	.	.
Nitrogen, nitrite, dissolved (as N)	x	.	.	x	.
Nitrogen, nitrite plus nitrate, dissolved (as N)	x	x	x	x	3
Nitrogen, ammonia, total (as N)	.	.	x	x	.
Nitrogen, ammonia, dissolved (as N)	x	x	.	.	3
Nitrogen, ammonia plus organic, total (as N)	.	x	x	x	3
Nitrogen, ammonia plus organic, dissolved (as N)	x	x	.	.	3
*Nitrogen, organic, total (as N)	.	.	x	.	.
*Nitrogen, organic, dissolved (as N)	x	x	.	.	3
Nitrogen, total (as N)	.	.	.	x	.
*Nitrogen, dissolved (as N)	x	x	.	.	3
Phosphorus, total (as P)	.	x	x	x	3
Phosphorus, dissolved (as P)	x	x	.	.	3
Phosphorus, orthophosphate, total (as P)	.	x	x	.	3
Phosphorus, orthophosphate, dissolved (as P)	x	x	.	.	3
Metals					
Aluminum, total recoverable and dissolved	2	2	2	2	.
Arsenic, total	2	x	2	x	3
Arsenic, dissolved	.	x	.	.	3
Cadmium, total recoverable and dissolved	.	1	.	1	3
Chromium, total recoverable	2	x	2	1	3
Chromium, dissolved	.	x	.	.	3
Copper, total recoverable and dissolved	2	x	2	x	3
Iron, total recoverable and dissolved	2	x	2	x	3
Lead, total recoverable and dissolved	x	x	x	x	3
Manganese, total recoverable and dissolved	2	2	2	2	.
Mercury, total recoverable	2	x	2	x	3
Mercury, dissolved	.	x	.	.	3
Nickel, total recoverable and dissolved	2	x	2	x	3
Zinc, total recoverable and dissolved	2	x	2	x	3
BIOLOGICAL					
Coliform, fecal, 0.7 µm-MF	.	x	.	.	3
OXYGEN DEMAND					
Oxygen demand, chemical, 0.25 N dichromate	x	x	.	x	3

*Calculated

Table 2. Quality constituents analyzed for in rainfall, runoff, atmospheric dry-deposition, and street-surface particulate samples—Continued

Property or constituent	Type of sample				
	Rainfall	Runoff	Atmospheric dry deposition	Street-surface particulate	Dry-weather runoff
OXYGEN DEMAND--Continued					
Oxygen demand, biochemical, carbonaceous, 5-day at 20°C	.	x	.	.	.
Oxygen demand, biochemical, carbonaceous, 20-day	.	x	.	.	.
PHYSICAL PROPERTIES					
Turbidity, NTU	.	x	.	.	3
Solids, residue at 180°C, dissolved	.	x	.	.	3
Solids, residue at 105°C, total	.	.	x	x	.
*Solids, sum of constituents, dissolved	.	x	x	.	3
Sediment, suspended	.	x	.	.	3
ORGANICS					
Carbon, organic, dissolved	x	x	x	.	3
Carbon, organic, suspended	.	x	.	.	.
Carbon, inorganic plus organic, total	.	.	.	x	.
Carbon, inorganic, total	.	.	.	x	.
Cyanide, total and dissolved	.	2	.	.	.
Oil and grease, total recoverable, gravimetric	.	x	.	.	.
Phenols, total recoverable	2	2	.	.	.
Polychlorinated biphenyls, total recoverable	x	x	2	x	3
Polychlorinated naphthalenes, total recoverable	x	x	2	x	3
Dibromochloropropane, total recoverable	.	1	.	.	.
Volatile organics					
Benzene, total recoverable	.	2	.	.	.
Chlorobenzene, total recoverable	.	2	.	.	.
Ethylbenzene, total recoverable	.	2	.	.	.
Organochlorine compounds					
Aldrin, total recoverable	x	x	2	x	3
Chlordane, total recoverable	x	x	2	x	3
DDD, total recoverable	x	x	2	x	3
DDE, total recoverable	x	x	2	x	3
DDT, total recoverable	x	x	2	x	3
Dieldrin, total recoverable	x	x	2	x	3
Endosulfan, total recoverable	x	x	2	x	3
Endrin, total recoverable	x	x	2	x	3
Heptachlor, total recoverable	x	x	2	x	3
Heptachlor epoxide, total recoverable	x	x	2	x	3
Lindane, total recoverable	x	x	2	x	3
Methoxychlor, total recoverable	x	x	2	x	3
Mirex, total recoverable	x	x	2	x	3
Perthane, total recoverable	x	x	2	x	3
Toxaphene, total recoverable	x	x	2	x	3
Organophosphorus compounds					
Diazinon, total recoverable	x	x	2	x	3
Ethion, total recoverable	x	x	2	x	3
Malathion, total recoverable	x	x	2	x	3
Methyl parathion, total recoverable	x	x	2	x	3
Methyl trithion, total recoverable	x	x	2	x	3
Parathion, total recoverable	x	x	2	x	3
Trithion, total recoverable	x	x	2	x	3
Carbamate insecticides					
Methomyl, total recoverable	1	1	.	.	.
Propham, total recoverable	1	1	.	.	.
Sevin, total recoverable	1	1	.	.	.
Chlorophenoxy acid herbicides					
Silvex, total recoverable	x	x	2	.	3
2,4-D, total recoverable	x	x	2	x	3
2,4-DP, total recoverable	x	x	2	.	3
2,4,5-T, total recoverable	x	x	2	.	3

Table 3. Average monthly rainfall totals for Fresno, California, compared to study period monthly rainfall totals

[National Weather Service data collected at Fresno Air Terminal]

Rainfall record	Monthly rainfall totals, in inches								
	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	8-month total
	Fresno Air Terminal								
104-year average	0.07	0.42	1.22	1.71	1.84	1.72	1.62	1.24	9.84
	Study period								
1981-82	0.00	0.58	1.22	0.65	2.11	0.58	4.76	0.89	10.79
1982-83	1.10	1.58	3.16	1.59	5.14	3.70	4.53	2.76	23.56

Table 4. Storm characteristics for storms monitored at four catchments

[Abbreviations: in., inch; ft^3/s, cubic foot per second; min, minute; h, hour; d, day; ., no data available]

Total runoff volume: Runoff volume not computed for some small storms; depth in inches covering the catchment drainage area.
Rainfall-runoff coefficient: Coefficient range 0 to 1; see page 17 for discussion of coefficients that are greater than 1.
Peak flow: If value is not shown, pipe flowed full and peak flow estimate was not considered reliable. The flow record for the single-dwelling residential catchment was affected by external electromagnetic field.
Time--
Since previous storm: Number of dry hours was not determined for first storms of each rain season.
Leader line is separation of rain seasons.

Storm duration				Rainfall total	Total runoff volume	Rainfall-runoff coefficient	Maximum 20-minute rainfall total	Peak flow	Rainfall duration	Runoff duration	Time	
First rainfall		End of runoff									Since previous storm	Since first storm
Date	Time	Date	Time	(in.)	(in.)		(in.)	(ft^3/s)	(min)	(min)	(h)	(d)
Industrial catchment												
10-28-81	0350	10-28-81	1200	0.30	0.022	0.07	0.11	4.8	325	250	.	1
11-12-81	2000	11-13-81	1232	0.58	0.054	0.09	0.06	1.0	764	956	352	16
11-17-81	0404	11-17-81	0856	0.25	0.018	0.07	0.07	3.4	164	248	72	21
11-28-81	1044	11-28-81	1840	0.15	0.009	0.06	0.02	0.8	296	348	45	32
12-29-81	1440	12-29-81	2230	0.18	0.024	0.13	0.03	2.7	342	380	194	63
01-01-82	2342	01-02-82	0140	0.10	0.001	0.01	0.07	0.2	52	48	75	66
01-04-82	0718	01-04-82	2114	0.62	0.169	0.27	0.04	7.4	646	744	49	69
01-04-82	2116	01-05-82	0320	0.16	0.042	0.26	0.04	4.1	176	364	1	69
01-19-82	2154	01-20-82	0144	0.11	0.010	0.09	0.04	2.3	60	188	358	84
01-20-82	0710	01-20-82	1942	0.17	0.023	0.14	0.04	3.3	700	580	8	85
01-21-82	0228	01-21-82	0640	0.06	0.005	0.08	0.03	0.9	80	210	15	86
01-26-82	1310	01-26-82	1736	0.04	.	.	0.01	0.3	116	146	129	91
02-13-82	1454	02-14-82	0208	0.06	0.005	0.08	0.01	0.5	456	260	432	109
02-14-82	1743	02-15-82	0930	0.28	0.052	0.19	0.05	4.4	668	910	19	110
02-15-82	1942	02-16-82	1006	0.25	0.075	0.30	0.03	5.0	564	812	18	111
03-01-82	0924	03-01-82	1610	0.21	0.033	0.16	0.04	4.0	168	358	316	125
03-01-82	2026	03-02-82	0326	0.13	0.021	0.16	0.05	2.3	186	344	5	125
03-09-82	1900	03-10-82	0946	0.33	0.035	0.11	0.06	2.5	590	838	173	133
03-10-82	2004	03-11-82	0706	0.20	0.048	0.24	0.07	6.2	414	432	15	134
03-11-82	0708	03-11-82	1654	0.09	0.032	0.36	0.01	1.7	500	578	4	135
03-11-82	1654	03-11-82	2332	0.06	.	.	0.04	3.9	328	396	5	135
03-14-82	0458	03-14-82	1828	0.73	0.233	0.32	0.06	16	548	754	59	138
03-16-82	0508	03-16-82	1426	0.22	0.065	0.30	0.04	5.5	330	388	39	140
03-16-82	1926	03-17-82	0646	0.25	0.100	0.40	0.06	6.5	414	658	9	140
03-17-82	2148	03-18-82	1200	0.13	0.057	0.44	0.03	3.7	564	846	21	141
03-18-82	1312	03-18-82	1712	0.05	0.015	0.30	0.03	3.8	240	224	2	142
03-18-82	1746	03-19-82	0238	0.18	0.053	0.29	0.04	8.1	272	430	2	142
03-25-82	2054	03-26-82	0422	0.24	0.033	0.14	0.05	4.8	308	362	168	149
03-28-82	0808	03-28-82	1208	0.09	0.005	0.06	0.02	1.1	110	162	50	152
03-28-82	1300	03-28-82	1616	0.17	0.015	0.09	0.16	4.5	194	194	1	152
03-28-82	1616	03-28-82	2202	0.47	0.117	0.25	0.22	18	170	342	1	152
03-28-82	2154	03-29-82	0118	0.06	0.012	0.20	0.05	2.8	48	196	1	152
03-29-82	1112	03-29-82	1738	0.23	0.035	0.15	0.06	7.1	202	284	13	153
03-31-82	1636	04-01-82	0826	1.01	0.136	0.14	0.13	5.8	864	916	1	155
04-10-82	0430	04-10-82	0902	0.23	0.020	0.09	0.07	4.1	184	240	216	165
04-10-82	1122	04-10-82	1508	0.16	0.030	0.19	0.07	5.5	122	212	4	165
04-10-82	1834	04-10-82	2340	0.22	0.034	0.16	0.04	4.1	192	240	5	165
09-24-82	0138	09-24-82	0800	0.20	0.005	0.02	0.05	0.7	334	230	.	1
10-25-82	0038	10-25-82	0556	0.19	0.002	0.01	0.14	0.6	242	190	720	32
10-26-82	0200	10-26-82	1202	0.59	0.106	0.18	0.22	4.5	334	562	22	33
10-30-82	0038	10-30-82	1134	0.67	0.099	0.15	0.08	8.2	474	574	89	37
11-09-82	1134	11-09-82	1828	0.45	0.045	0.10	0.06	7.4	242	378	18	47
11-18-82	0540	11-18-82	1248	0.17	0.009	0.05	0.03	1.2	288	260	115	56
11-18-82	1640	11-19-82	0130	0.52	0.082	0.16	0.18	13	520	414	6	56
11-29-82	1416	11-29-82	2154	0.50	0.090	0.18	0.07	11	380	373	39	67
12-22-82	0141	12-22-82	1436	0.64	0.199	0.31	0.06	15	646	666	1	90
01-18-83	1642	01-19-83	0328	0.78	0.257	0.33	0.11	28	418	502	56	117
01-22-83	1608	01-22-83	2236	0.84	0.154	0.18	0.39	20	190	356	4	121
01-23-83	2216	01-24-83	1228	0.70	0.143	0.20	0.22	18	702	686	30	122

Table 4. Storm characteristics for storms monitored at four catchments—Continued

Storm duration				Rain-fall total	Total runoff volume	Rainfall-runoff coeffi-cient	Maximum 20-minute rainfall total	Peak flow	Rainfall duration	Runoff duration	Time	
First rainfall		End of runoff									Since previous storm	Since first storm
Date	Time	Date	Time	(in.)	(in.)		(in.)	(ft^3/s)	(min)	(min)	(h)	(d)
Single-dwelling residential catchment												
10-28-81	0650	10-28-81	1015	0.30	*0.041	0.14	0.14	.	125	160	.	1
11-12-81	1944	11-13-81	0040	0.27	*0.041	0.15	0.06	.	224	268	334	16
11-13-81	0100	11-13-81	1004	0.30	*0.083	0.28	0.03	.	440	452	2	17
11-17-81	0400	11-17-81	0756	0.25	*0.044	0.18	0.04	.	192	196	72	21
03-25-82	2056	03-26-82	0240	0.20	*0.031	0.15	0.03	.	252	244	168	149
03-28-82	1254	03-28-82	1412	0.09	*0.018	0.20	0.09	.	8	66	3	152
03-28-82	1556	03-28-82	1714	0.16	*0.037	0.23	0.15	.	24	74	3	152
03-29-82	1122	03-29-82	1606	0.17	*0.032	0.19	0.04	.	212	166	19	153
03-29-82	1704	03-29-82	1828	0.03	*0.005	0.17	0.02	.	24	62	2	153
03-31-82	1628	03-31-82	2320	0.95	*0.235	0.25	0.09	.	388	392	48	155
04-10-82	0446	04-10-82	0834	0.16	*0.023	0.14	0.04	.	186	192	204	165
09-24-82	0120	09-24-82	0550	0.22	*0.028	0.13	0.08	.	192	128	.	1
09-25-82	0948	09-25-82	2220	0.91	*0.234	0.26	0.06	.	712	620	31	2
10-25-82	0220	10-25-82	0432	0.09	*0.010	0.11	0.08	.	46	94	699	32
10-26-82	0148	10-26-82	0512	0.69	*0.173	0.25	0.20	.	146	178	23	33
12-21-82	1238	12-21-82	1606	0.10	0.017	0.17	0.04	1.2	106	160	511	89
12-21-82	1748	12-21-82	2340	0.17	0.047	0.28	0.03	2.0	308	322	3	89
12-22-82	1446	12-22-82	1732	0.37	0.124	0.34	0.23	15	80	152	5	90
01-18-83	1734	01-19-83	0106	0.85	0.171	0.20	0.11	5.5	390	380	56	117
01-21-83	2100	01-22-83	0110	0.10	0.014	0.14	0.03	1.1	172	154	71	120
01-22-83	0450	01-22-83	1354	0.73	0.173	0.24	0.11	6.9	496	524	5	121
01-24-83	0006	01-24-83	0710	0.27	0.063	0.23	0.06	2.5	366	412	29	123
01-24-83	0830	01-24-83	1136	0.47	0.172	0.37	0.36	19	100	180	3	123
01-26-83	1938	01-27-83	1138	1.39	0.404	0.29	0.12	5.8	936	908	58	125
01-28-83	2124	01-29-83	0418	0.39	0.097	0.25	0.05	4.7	386	372	35	127
02-06-83	0530	02-06-83	2400	0.85	0.138	0.16	0.07	3.6	1088	1000	195	136
02-07-83	2142	02-08-83	0104	0.44	0.113	0.26	0.14	8.5	116	192	16	137
02-12-83	1114	02-12-83	2124	0.33	0.061	0.18	0.04	2.4	574	538	108	142
02-25-83	1340	02-25-83	1802	0.22	0.023	0.10	0.05	1.1	250	208	168	155
02-28-83	1610	03-01-83	0438	1.11	0.301	0.27	0.16	17	646	638	31	158
03-01-83	1806	03-01-83	2018	0.11	0.024	0.22	0.08	2.7	28	126	15	159
03-07-83	0038	03-07-83	0420	0.14	0.016	0.11	0.03	0.7	152	180	100	165
03-10-83	1932	03-10-83	2348	0.19	0.027	0.14	0.11	2.7	154	144	88	168
03-13-83	0554	03-13-83	1700	0.70	0.194	0.28	0.27	12	560	570	55	171
03-16-83	1640	03-16-83	2040	0.40	0.077	0.19	0.10	5.1	148	218	74	174
03-17-83	1836	03-18-83	0028	0.46	0.091	0.20	0.09	5.0	326	254	2	175
03-20-83	1908	03-20-83	2352	0.29	0.044	0.15	0.05	2.5	208	238	64	178
03-22-83	0844	03-22-83	1252	0.14	0.022	0.16	0.03	1.0	192	200	34	180
03-22-83	1634	03-22-83	1818	0.08	0.012	0.15	0.08	1.2	10	98	5	180
03-23-83	1924	03-23-83	2346	0.57	0.134	0.24	0.10	8.2	140	226	27	181
03-24-83	0750	03-24-83	1010	0.30	0.071	0.24	0.25	8.6	32	140	10	182
03-24-83	1358	03-24-83	1808	0.16	0.041	0.26	0.06	2.4	222	194	6	182
Multiple-dwelling residential catchment												
10-28-81	0650	10-28-81	1105	0.34	0.155	0.46	0.19	12	125	240	.	1
10-28-81	2005	10-28-81	2250	0.05	.	.	0.03	0.5	55	115	9	1
10-29-81	0140	10-29-81	0400	0.04	.	.	0.03	0.3	70	115	3	2
11-12-81	1944	11-13-81	0100	0.27	0.045	0.17	0.06	1.0	228	292	352	16
11-13-81	0104	11-13-81	0940	0.33	0.060	0.18	0.03	0.7	436	516	1	17
11-13-81	2228	11-14-81	0036	0.13	0.029	0.22	0.09	2.0	44	112	13	17
11-17-81	0400	11-17-81	0800	0.29	0.061	0.21	0.10	2.5	216	224	71	21
11-26-81	1300	11-26-81	1624	0.11	0.011	0.10	0.04	0.3	152	168	221	30
11-27-81	0704	11-27-81	1056	0.09	0.009	0.10	0.03	0.3	160	116	14	31
12-20-81	0332	12-20-81	0958	0.09	0.013	0.14	0.03	0.4	302	122	241	54
12-20-81	1350	12-20-81	1630	0.06	0.019	0.32	0.03	0.7	60	136	4	54

Table 4. Storm characteristics for storms monitored at four catchments—Continued

Storm duration				Rain-fall total	Total runoff volume	Rainfall-runoff coeffi-cient	Maximum 20-minute rainfall total	Peak flow	Rainfall duration	Runoff duration	Time	
First rainfall		End of runoff									Since previous storm	Since first storm
Date	Time	Date	Time	(in.)	(in.)		(in.)	(ft^3/s)	(min)	(min)	(h)	(d)
Multiple-dwelling residential catchment--Continued												
12-21-81	0552	12-21-81	0908	0.06	0.007	0.12	0.04	0.3	118	78	14	55
12-29-81	1354	12-29-81	2042	0.24	0.049	0.20	0.07	0.9	360	350	198	63
12-30-81	0146	12-30-81	0408	0.14	0.030	0.21	0.06	1.0	130	126	5	64
01-01-82	0114	01-01-82	0354	0.08	0.013	0.16	0.05	0.7	70	104	46	66
01-01-82	2330	01-02-82	0202	0.08	0.014	0.18	0.07	0.6	76	108	21	66
01-04-82	0656	01-04-82	2008	0.83	0.289	0.35	0.04	2.1	694	724	50	69
01-04-82	2110	01-05-82	0304	0.33	0.140	0.42	0.06	3.2	248	354	2	69
01-19-82	2202	01-02-82	0052	0.14	0.045	0.32	0.05	1.7	74	148	351	84
01-20-82	0752	01-20-82	1306	0.18	0.052	0.29	0.03	1.4	242	272	9	85
01-21-82	0232	01-21-82	0456	0.06	0.011	0.18	0.03	0.5	72	106	7	86
01-21-82	1336	01-21-82	1622	0.27	0.058	0.22	0.06	5.7	164	120	10	86
02-14-82	1740	02-14-82	2012	0.11	0.028	0.26	0.05	1.6	80	120	461	110
02-14-82	2028	02-15-82	0130	0.17	0.046	0.27	0.03	0.8	254	274	3	110
02-15-82	2000	02-16-82	0102	0.26	0.105	0.40	0.05	2.0	186	280	19	111
02-16-82	0338	02-16-82	0710	0.11	0.051	0.46	0.04	1.3	112	192	1	112
03-09-82	1846	03-09-82	2320	0.16	0.028	0.18	0.04	0.6	194	218	199	133
03-10-82	0100	03-10-82	0700	0.31	0.113	0.36	0.11	5.8	220	328	2	134
03-10-82	2306	03-11-82	0330	0.25	0.084	0.34	0.07	3.2	202	232	16	134
03-11-82	0626	03-11-82	0900	0.05	0.012	0.24	0.03	0.5	46	124	3	135
03-11-82	1320	03-11-82	1910	0.19	0.060	0.32	0.05	1.6	330	308	5	135
03-14-82	0146	03-14-82	1550	0.92	0.428	0.46	0.10	8.9	750	608	55	138
03-16-82	0456	03-16-82	1316	0.44	0.153	0.35	0.07	3.8	396	384	37	140
03-16-82	1948	03-17-82	0248	0.31	0.113	0.36	0.06	2.3	312	438	7	140
03-18-82	0350	03-18-82	0910	0.20	0.060	0.30	0.04	1.2	208	292	6	142
03-18-82	1308	03-18-82	1600	0.17	0.073	0.43	0.09	4.9	54	152	4	142
03-18-82	1836	03-18-82	2220	0.10	0.022	0.22	0.03	0.6	148	174	3	142
03-25-82	2100	03-26-82	0348	0.26	0.063	0.24	0.05	1.1	256	324	167	149
03-28-82	0818	03-28-82	1152	0.06	0.010	0.17	0.02	0.4	100	156	52	152
03-28-82	1246	03-28-82	1510	0.06	0.020	0.33	0.06	1.7	16	122	1	152
03-29-82	1104	03-29-82	1700	0.27	0.092	0.34	0.06	2.8	236	306	20	153
03-29-82	1702	03-29-82	2024	0.10	0.042	0.42	0.09	2.9	30	200	1	153
03-31-82	1630	04-01-82	1030	1.07	0.580	0.54	0.12	6.2	942	1080	44	155
04-01-82	1602	04-01-82	1844	0.15	0.055	0.37	0.10	3.0	48	162	6	156
04-10-82	0448	04-10-82	0920	0.17	0.046	0.27	0.04	1.0	172	272	202	165
04-10-82	1056	04-10-82	1444	0.19	0.059	0.31	0.08	2.5	134	192	2	165
04-10-82	1834	04-10-82	2332	0.25	0.083	0.33	0.04	1.8	202	264	4	165
04-11-82	0108	04-11-82	0258	0.04	0.009	0.22	0.02	0.3	40	104	2	166
04-11-82	0516	04-11-82	0810	0.10	0.042	0.42	0.05	1.5	66	168	2	166
09-24-82	0144	09-24-82	0658	0.23	0.069	0.30	0.08	3.1	208	208	.	1
09-24-82	0658	09-24-82	1022	0.05	0.005	0.10	0.02	0.2	158	118	1	1
09-25-82	1024	09-25-82	1150	0.02	0.003	0.15	0.02	0.2	86	62	23	2
09-25-82	1200	09-26-82	0232	0.99	0.364	0.37	0.07	4.9	814	850	1	2
10-25-82	0146	10-25-82	0458	0.09	0.021	0.23	0.08	1.5	72	118	652	32
10-26-82	0150	10-26-82	0602	0.71	0.528	0.74	0.21	22	150	226	23	33
10-30-82	0032	10-30-82	0956	0.65	0.242	0.37	0.06	3.2	472	506	89	37
10-30-82	1416	10-30-82	1732	0.27	0.242	0.90	0.23	20	118	180	6	37
11-09-82	1028	11-09-82	1744	0.45	0.170	0.38	0.04	4.4	324	340	16	47
11-18-82	0508	11-18-82	1212	0.37	0.130	0.35	0.07	5.1	336	268	192	56
11-28-82	1704	11-28-82	2328	0.51	0.290	0.57	0.12	12	288	286	21	66
11-29-82	1410	11-29-82	2238	0.76	0.493	0.65	0.16	22	416	464	10	67
11-30-82	0002	11-30-82	0250	0.09	0.024	0.27	0.05	0.7	86	154	3	68
11-30-82	0356	11-30-82	0910	0.45	0.348	0.77	0.18	19	166	314	3	68
12-21-82	1238	12-21-82	1538	0.11	0.021	0.19	0.04	0.7	86	146	504	89
12-21-82	1750	12-22-82	0006	0.21	0.062	0.30	0.04	1.7	316	350	4	89
12-22-82	0124	12-22-82	1404	0.71	0.330	0.46	0.08	6.1	668	712	3	90
01-18-83	1814	01-19-83	0204	0.95	0.462	0.49	0.11	11	350	444	56	117
01-21-83	1444	01-21-83	1802	0.04	0.003	0.08	0.02	0.1	98	98	63	120
01-21-83	2054	01-22-83	0132	0.11	0.030	0.27	0.04	1.5	154	188	4	120
01-22-83	0320	01-22-83	1628	0.86	0.500	0.58	0.13	13	674	666	4	121

Table 4. Storm characteristics for storms monitored at four catchments—Continued

Storm duration				Rainfall total	Total runoff volume	Rainfall-runoff coefficient	Maximum 20-minute rainfall total	Peak flow	Rainfall duration	Runoff duration	Time	
First rainfall		End of runoff									Since previous storm	Since first storm
Date	Time	Date	Time	(in.)	(in.)		(in.)	(ft^3/s)	(min)	(min)	(h)	(d)
Multiple-dwelling residential catchment--Continued												
01-22-83	1616	01-22-83	2400	0.78	0.787	1.01	0.34	.	218	450	2	121
01-23-83	2230	01-24-83	0840	0.34	0.155	0.46	0.10	3.8	470	502	27	122
01-24-83	0832	01-24-83	1422	0.47	0.443	0.94	0.40	.	98	340	2	123
01-26-83	1946	01-27-83	1600	1.69	1.188	0.70	0.12	18	984	1176	48	125
01-28-83	2138	01-29-83	0552	0.47	0.262	0.56	0.10	9.5	324	466	35	127
02-07-83	1526	02-08-83	0320	0.48	0.371	0.77	0.12	16	500	690	17	137
02-12-83	1016	02-13-83	0006	0.40	0.100	0.25	0.05	2.5	772	680	94	142
02-13-83	0156	02-13-82	0438	0.11	0.037	0.34	0.08	2.1	114	152	4	143
02-18-83	0718	02-18-83	1018	0.24	0.122	0.51	0.17	8.9	70	178	124	148
02-25-83	1328	02-25-83	2158	0.35	0.128	0.37	0.05	3.0	348	456	173	155
02-28-83	0652	02-28-83	1018	0.04	0.009	0.22	0.02	0.3	40	174	22	158
02-28-83	1624	02-28-83	2224	0.21	0.102	0.49	0.09	4.5	222	332	9	158
02-28-83	2204	03-01-83	0626	0.92	0.965	1.05	0.18	.	300	480	2	158
03-16-83	1642	03-16-83	2218	0.40	0.213	0.53	0.10	8.5	146	314	74	174
03-17-83	1552	03-18-83	0532	0.57	0.375	0.66	0.10	13	654	800	21	175
03-20-83	1918	03-21-83	0128	0.33	0.136	0.41	0.05	4.6	226	338	65	178
03-23-83	1918	03-24-83	0052	0.57	0.503	0.88	0.11	19	148	294	23	181
03-24-83	0610	03-24-83	1124	0.22	0.199	0.90	0.14	14	144	208	9	182
03-24-83	1406	03-24-83	1914	0.22	0.142	0.65	0.06	6.2	162	272	6	182
03-24-83	2048	03-24-83	2332	0.07	0.039	0.56	0.05	1.4	66	146	4	182
Commercial catchment												
10-28-81	0650	10-28-81	1250	0.27	0.315	1.17	0.18	19	105	330	.	1
11-17-81	0356	11-17-81	0816	0.25	0.234	0.94	0.08	14	160	240	72	21
11-26-81	1236	11-26-81	1700	0.11	0.069	0.63	0.03	3.1	168	224	222	30
11-27-81	0752	11-27-81	1236	0.09	0.059	0.66	0.03	3.4	104	244	16	31
11-27-81	1408	11-27-81	1640	0.03	0.007	0.23	0.03	0.8	36	132	4	31
11-27-81	1752	11-27-81	2036	0.06	0.032	0.53	0.06	9.5	8	156	1	31
11-28-81	1152	11-28-81	1548	0.07	0.031	0.44	0.02	1.4	144	180	16	32
12-20-81	0326	12-20-81	1718	0.14	0.166	1.19	0.02	3.7	692	792	240	54
12-21-81	0710	12-21-81	1020	0.03	0.024	0.80	0.02	1.7	22	152	16	55
12-29-81	1414	12-29-81	2150	0.21	0.183	0.87	0.04	7.0	338	418	199	63
12-30-81	0142	12-30-81	0444	0.13	0.131	1.01	0.05	9.3	54	168	6	64
01-01-82	0128	01-01-82	0420	0.09	0.084	0.93	0.05	9.0	66	136	47	66
01-01-82	2344	01-02-82	0238	0.07	0.054	0.77	0.04	4.0	60	148	21	66
01-02-82	0558	01-02-82	0820	0.02	.	.	0.02	0.6	20	106	5	67
01-02-82	1312	01-02-82	1520	0.04	0.009	0.23	0.03	0.6	32	92	7	67
01-04-82	0732	01-04-82	2100	0.71	0.772	1.09	0.04	7.2	656	786	42	69
01-04-82	2112	01-05-82	0450	0.26	0.310	1.19	0.06	9.8	230	434	3	69
01-05-82	1356	01-05-82	1600	0.02	.	.	0.02	0.8	8	90	13	70
01-19-82	2202	01-20-82	0100	0.09	0.085	0.94	0.03	6.1	58	146	341	84
01-20-82	0754	01-20-82	1300	0.13	0.117	0.90	0.03	5.4	226	264	9	85
01-20-82	1632	01-20-82	1800	0.02	.	.	0.02	1.0	4	62	5	85
01-21-82	1326	01-21-82	1718	0.20	0.206	1.03	0.09	20	98	210	10	86
01-26-82	1418	01-26-82	1630	0.06	0.048	0.80	0.03	4.5	98	110	119	91
02-14-82	1744	02-14-82	2046	0.10	0.096	0.96	0.05	7.9	78	160	453	110
02-14-82	2032	02-15-82	0248	0.18	0.214	1.19	0.03	4.3	290	360	1	110
02-15-82	0812	02-15-82	1032	0.05	0.049	0.98	0.04	3.8	46	132	7	111
02-15-82	1958	02-16-82	0140	0.22	0.274	1.24	0.05	7.9	180	320	11	111
02-16-82	0314	02-16-82	1002	0.15	0.185	1.23	0.04	6.4	292	392	4	112
03-09-82	1838	03-09-82	2344	0.17	0.151	0.89	0.03	4.5	304	266	189	133
03-09-82	2350	03-10-82	0640	0.26	0.276	1.06	0.08	14	390	404	2	133
03-10-82	2258	03-11-82	0330	0.28	0.285	1.02	0.06	10	208	254	18	134
03-11-82	0624	03-11-82	1024	0.06	0.068	1.13	0.03	3.7	224	220	5	135
03-11-82	1008	03-11-82	2040	0.26	0.201	0.77	0.03	5.9	454	610	3	135
03-14-82	0312	03-14-82	1630	0.89	0.959	1.08	0.15	30	664	768	58	138
03-16-82	0512	03-16-82	1338	0.41	0.439	1.07	0.06	11	492	458	39	140
03-16-82	1946	03-17-82	0222	0.29	0.320	1.10	0.08	15	298	380	8	140
03-17-82	2202	03-18-82	0028	0.03	0.016	0.53	0.03	1.6	152	112	21	141

Table 4. Storm characteristics for storms monitored at four catchments—Continued

Storm duration				Rain-fall total	Total runoff volume	Rainfall-runoff coeffi-cient	Maximum 20-minute rainfall total	Peak flow	Rainfall duration	Runoff duration	Time	
First rainfall		End of runoff									Since previous storm	Since first storm
Date	Time	Date	Time	(in.)	(in.)		(in.)	(ft³/s)	(min)	(min)	(h)	(d)
Commercial catchment--Continued												
03-18-82	0348	03-18-82	0956	0.22	0.211	0.96	0.04	5.9	296	342	5	142
03-18-82	1308	03-18-82	1600	0.14	0.151	1.08	0.08	13	146	150	4	142
03-18-82	1834	03-18-82	2328	0.09	0.101	1.12	0.03	4.8	120	246	4	142
03-25-82	2208	03-26-82	0250	0.19	0.148	0.78	0.04	4.9	190	252	170	149
03-28-82	0836	03-28-82	1108	0.06	0.029	0.48	0.03	2.2	80	106	55	152
03-28-82	1232	03-28-82	1430	0.07	0.053	0.76	0.05	6.0	24	98	2	152
03-28-82	1548	03-28-82	1724	0.11	0.079	0.72	0.11	12	16	92	3	152
03-29-82	1140	03-29-82	1658	0.17	0.210	1.24	0.05	9.5	288	282	13	153
03-29-82	1700	03-29-82	1910	0.07	0.101	1.44	0.05	12	28	126	2	153
03-31-82	1630	04-01-82	0920	1.05	1.179	1.12	0.12	20	900	1006	49	155
04-01-82	1544	04-01-82	1908	0.27	0.297	1.10	0.20	30	80	184	8	156
04-10-82	0444	04-10-82	0934	0.18	0.174	0.97	0.05	8.0	182	258	216	165
04-10-82	1112	04-10-82	1434	0.17	0.159	0.94	0.07	11	146	190	5	165
04-10-82	1846	04-11-82	0020	0.22	0.231	1.05	0.04	8.1	190	306	8	165
04-11-82	0106	04-11-82	0320	0.04	.	.	0.03	2.3	30	122	28	166
04-11-82	0516	04-11-82	0836	0.12	0.121	1.01	0.07	7.5	82	196	5	166
09-24-82	0132	09-24-82	0812	0.24	0.231	0.96	0.09	16	200	338	.	1
10-24-82	0548	10-24-82	0902	0.02	0.007	0.35	0.02	0.3	26	122	675	31
10-25-82	0244	10-25-82	0518	0.05	0.052	1.04	0.05	5.0	18	142	18	32
10-26-82	0146	10-26-82	0626	0.61	0.844	1.38	0.20	.	148	278	23	33
11-08-82	1710	11-08-82	2028	0.14	0.155	1.11	0.07	14	106	182	222	46
11-09-82	1020	11-09-82	1850	0.47	0.648	1.38	0.07	14	296	500	14	47
12-21-82	1222	12-21-82	1632	0.09	0.076	0.84	0.04	4.6	90	220	29	89
12-21-82	1744	12-22-82	0136	0.18	0.201	1.12	0.04	7.2	326	454	4	89
12-22-82	0134	12-22-82	1850	1.05	1.525	1.45	0.18	.	866	1032	1	90
01-18-83	1614	01-19-83	0134	0.88	1.080	1.23	0.13	.	444	498	56	117
01-24-83	0002	01-24-83	0824	0.30	0.266	0.89	0.08	11	370	486	27	123
01-24-82	0816	01-24-83	1336	0.48	0.705	1.47	0.39	.	100	310	1	123
02-28-83	0646	02-28-83	1040	0.05	0.027	0.54	0.02	1.5	44	202	21	158
02-28-83	1636	03-01-83	0832	1.10	1.472	1.34	0.15	.	610	868	9	158
03-01-83	1806	03-02-83	0048	0.07	0.101	1.44	0.06	8.7	18	388	15	159
03-02-83	0204	03-02-83	0806	0.08	0.106	1.32	0.04	4.5	146	338	8	160
03-16-83	1640	03-16-83	2110	0.40	0.451	1.13	0.11	20	144	256	74	174
03-22-83	1630	03-22-83	1944	0.07	0.061	0.87	0.07	6.7	6	188	4	180
03-22-83	2104	03-23-83	0038	0.03	0.026	0.87	0.02	1.3	30	186	5	180
03-23-83	1934	03-24-83	0308	0.57	0.873	1.53	0.11	.	130	430	22	181
03-24-83	0652	03-24-83	1116	0.30	0.394	1.31	0.24	.	92	210	9	182

*Calculated using rainfall-runoff equation; original flow record affected by external electromagnetic field.

Table 5. Statistical summary of storm characteristics for storms monitored at four catchments

Storm characteristic	Mean	Standard error of mean	Standard deviation	Maximum	Minimum
Industrial catchment (number of storms = 47)					
Rainfall total (in.)	0.32	0.04	0.24	1.01	0.05
Runoff volume (in.)	0.060	0.009	0.062	0.257	0.001
Rainfall-runoff coefficient	0.18	0.02	0.11	0.44	0.01
Maximum 20-minute rainfall total (in.)	0.08	0.01	0.07	0.39	0.01
Rainfall duration (min)	355	35	237	864	48
Runoff duration (min)	436	31	209	956	48
Single-dwelling residential catchment (number of storms = 42)					
Rainfall total (in.)	0.38	0.05	0.32	1.39	0.03
Runoff volume (in.)	0.088	0.014	0.088	0.404	0.005
Rainfall-runoff coefficient	0.21	0.01	0.06	0.37	0.10
Maximum 20-minute rainfall total (in.)	0.10	0.01	0.07	0.36	0.02
Rainfall duration (min)	270	38	244	1,088	8
Runoff duration (min)	286	33	215	1,000	62
Multiple-dwelling residential catchment (number of storms = 88)					
Rainfall total (in.)	0.32	0.03	0.30	1.69	0.02
Runoff volume (in.)	0.161	0.023	0.216	1.188	0.003
Rainfall-runoff coefficient	0.39	0.02	0.22	1.05	0.08
Maximum 20-minute rainfall total (in.)	0.08	0.01	0.06	0.40	0.02
Rainfall duration (min)	247	23	214	984	16
Runoff duration (min)	307	23	218	1,176	62
Commercial catchment[1] (number of storms = 49)					
Rainfall total (in.)	0.19	0.03	0.20	1.05	0.03
Runoff volume (in.)	0.198	0.032	0.226	1.179	0.007
Rainfall-runoff coefficient	0.93	0.04	0.26	1.44	0.22
Maximum 20-minute rainfall total (in.)	0.06	0.01	0.04	0.20	0.02
Rainfall duration (min)	206	28	196	900	8
Runoff duration (min)	286	29	202	1,006	92

[1] Only first rain season storms included because of variable backwater situation during second rain season (Oltmann and others, 1987).

Table 6. Statistical summary of rainfall quality data: Industrial site

[Statistical calculations include analytical detection limit concentration for those analyses which are reported to be less than detection limit. Other pesticides were analyzed for but not detected and are given at the end of this table. <, actual value is less than value shown]

Property or constituent	Number of samples	Mean	Median	Standard error of mean	Standard deviation	Maximum	Minimum
INORGANICS							
Field measurements							
Specific conductance (μS/cm at 25°C)	36	14	11	2	10	52	3
pH (units)	37	6.4	6.3	0.1	0.6	7.7	5.0
Major ions (mg/L)							
Calcium, dissolved	15	0.58	0.33	0.11	0.43	1.5	0.10
Magnesium, dissolved	15	0.09	0.10	0.02	0.06	0.24	<0.01
Sodium, dissolved	15	0.5	0.4	0.1	0.3	1.2	0.2
Potassium, dissolved	15	0.2	0.2	0.1	0.1	0.6	0.1
Alkalinity, total (as $CaCO_3$)	15	8	8	0	2	10	4
Sulfate, dissolved	12	3.2	<5.0	0.6	2.2	5.0	0.6
Chloride, dissolved	15	0.5	0.5	0.1	0.2	1.0	0.2
Silica, dissolved	7	0.29	0.40	0.09	0.25	0.60	0.01
Nutrients (mg/L)							
Nitrogen, nitrite, dissolved (as N)	12	0.02	<0.02	0.00	0.01	0.04	<0.02
Nitrogen, nitrite plus nitrate, dissolved (as N)	15	0.25	0.13	0.06	0.23	0.96	<0.09
Nitrogen, ammonia, dissolved (as N)	12	0.66	0.62	0.09	0.32	1.3	0.19
Nitrogen, ammonia plus organic dissolved (as N)	14	1.4	1.1	0.26	0.97	4.0	0.59
Nitrogen, organic, dissolved (as N)	9	0.70	0.47	0.27	0.80	2.7	0.08
Nitrogen, dissolved (as N)	10	1.9	1.4	0.40	1.3	4.2	0.93
Phosphorus, dissolved (as P)	15	0.08	0.05	0.02	0.08	0.28	0.01
Phosphorus, orthophosphate, dissolved (as P)	12	0.02	0.01	0.00	0.02	0.06	<0.01
Metals (μg/L)							
Aluminum, total recoverable	4	210	100	120	250	580	60
Aluminum, dissolved	3	10	10	0	0	10	<10
Arsenic, total	7	1	<1	0	0	<1	<1
Chromium, total recoverable	4	1	<1	0	0	1	<1
Copper, total recoverable	4	6	6	2	4	12	1
Copper, dissolved	3	1	1	0	0	1	<1
Iron, total recoverable	9	490	130	300	900	2,800	10
Iron, dissolved	8	9	8	2	6	18	<3
Lead, total recoverable	15	11	7	3	12	51	<1
Lead, dissolved	13	2	1	0	1	4	<1
Manganese, total recoverable	9	20	10	10	20	80	<10
Manganese, dissolved	8	5	2	2	7	21	<1
Mercury, total recoverable	7	0.1	<0.1	0.0	0.0	0.2	<0.1
Nickel, total recoverable	9	5	5	1	4	11	<1
Nickel, dissolved	8	2	2	0	2	5	<1
Zinc, total recoverable	4	60	55	10	30	90	30
Zinc, dissolved	3	24	22	5	9	34	17
OXYGEN DEMAND							
Oygen demand, chemical, 0.25 N dichromate (mg/L)	14	16	14	2	6	27	<10
ORGANICS							
Carbon, organic, dissolved (mg/L as C)	14	3.8	4.0	0.4	1.4	6.2	0.8
Phenols, total recoverable (μg/L)	10	5	4	1	4	15	2

Table 6. Statistical summary of rainfall quality data: Industrial site—Continued

Property or constituent	Number of samples	Mean	Median	Standard error of mean	Standard deviation	Maximum	Minimum
ORGANICS--Continued							
Pesticides (total recoverable, µg/L)							
Chlordane	20	0.12	<0.10	0.02	0.07	0.40	<0.10
DDE	20	0.01	<0.01	0.00	0.00	0.02	<0.01
Diazinon	21	0.18	0.14	0.04	0.21	0.93	0.01
Dieldrin	20	0.01	<0.01	0.00	0.00	0.02	<0.01
Endosulfan	20	0.02	<0.01	0.00	0.02	0.08	<0.01
Lindane	20	0.02	0.01	0.00	0.01	0.04	<0.01
Methoxychlor	20	0.02	<0.01	0.01	0.03	0.12	<0.01
Malathion	21	0.03	0.02	0.01	0.03	0.11	<0.01
Parathion	21	0.28	0.16	0.06	0.28	1.0	<0.01
2,4-D	15	0.02	<0.01	0.01	0.02	0.08	<0.01

Other pesticides analyzed but not detected

Pesticide (total recoverable)	Detection limit (µg/L)	Number of samples	Pesticide (total recoverable)	Detection limit (µg/L)	Number of samples
Aldrin	0.01	20	Methyl parathion	0.01	21
DDD	0.01	20	Methyl trithion	0.01	21
DDT	0.01	20	Mirex	0.01	20
Endrin	0.01	20	Perthane	0.1	20
Ethion	0.01	21	Propham	2	5
Gross polychlorinated biphenyls	0.01	20	Sevin	2	5
			Silvex	0.01	15
Gross polychlorinated naphthalenes	0.1	20	Toxaphene	1	20
Heptachlor	0.01	20	Trithion	0.01	21
Heptachlor epoxide	0.01	20	2,4-DP	0.01	15
Methomyl	2	5	2,4,5-T	0.01	15

Table 7. Statistical summary of rainfall quality data: Single-dwelling residential site

[Statistical calculations include analytical detection limit concentration for those analyses which are reported to be less than detection limit. Other pesticides were analyzed for but not detected and are given at the end of this table. <, actual value is less than value shown]

Property or constituent	Number of samples	Mean	Median	Standard error of mean	Standard deviation	Maximum	Minimum
INORGANICS							
Field measurements							
Specific conductance (µS/cm at 25°C)	32	14	11	2	13	57	2
pH (units)	33	5.9	5.8	0.1	0.8	7.7	4.7
Major ions (mg/L)							
Calcium, dissolved	16	0.48	0.46	0.08	0.31	1.3	0.14
Magnesium, dissolved	16	0.08	0.10	0.01	0.05	0.18	<0.01
Sodium, dissolved	16	0.5	0.5	0.1	0.2	1.1	<0.2
Potassium, dissolved	16	0.1	0.1	0.0	0.1	0.3	<0.1

Table 7. Statistical summary of rainfall quality data: Single-dwelling residential site—Continued

Property or constituent	Number of samples	Mean	Median	Standard error of mean	Standard deviation	Maximum	Minimum
INORGANICS--Continued							
Major ions (mg/L)--Continued							
Alkalinity, total (as $CaCO_3$)	16	7	7	0	2	9	3
Sulfate, dissolved	14	3.4	5.0	0.6	2.2	5.0	0.5
Chloride, dissolved	16	0.5	0.4	0.1	0.3	1.2	0.1
Silica, dissolved	8	0.25	0.24	0.09	0.25	0.60	<0.01
Nutrients (mg/L)							
Nitrogen, nitrite, dissolved (as N)	13	0.02	<0.02	0.00	0.01	0.04	<0.02
Nitrogen, nitrite plus nitrate, dissolved (as N)	16	0.22	0.13	0.04	0.17	0.60	0.04
Nitrogen, ammonia, dissolved (as N)	13	0.37	0.35	0.06	0.22	0.74	0.11
Nitrogen, ammonia plus organic, dissolved (as N)	14	1.4	0.70	0.64	2.4	9.7	0.30
Nitrogen, organic, dissolved (as N)	10	0.43	0.35	0.08	0.24	0.99	0.10
Nitrogen, dissolved (as N)	10	2.0	1.1	0.90	2.8	10	0.40
Phosphorus, dissolved (as N)	16	0.03	0.01	0.01	0.04	0.14	<0.01
Phosphorus, orthophosphate, dissolved (as P)	13	0.01	0.01	0.00	0.01	0.04	<0.01
Metals (µg/L)							
Aluminum, total recoverable	3	50	50	10	20	80	30
Aluminum, dissolved	3	20	10	10	10	30	<10
Arsenic, total	7	1	<1	0	0	<1	<1
Chromium, total recoverable	3	1	<1	0	0	<1	<1
Copper, total recoverable	3	4	4	1	2	6	<1
Copper, dissolved	3	2	1	1	1	3	1
Iron, total recoverable	9	330	90	160	470	1,400	10
Iron, dissolved	8	8	4	3	8	24	<3
Lead, total recoverable	16	12	8	4	14	61	<1
Lead, dissolved	14	2	1	1	3	11	<1
Manganese, total recoverable	9	20	10	10	20	60	<10
Manganese, dissolved	8	4	2	2	5	17	<1
Mercury, total recoverable	7	0.1	0.1	0.0	0.0	0.1	<0.1
Nickel, total recoverable	9	7	5	1	4	12	<1
Nickel, dissolved	8	2	2	0	1	3	<1
Zinc, total recoverable	3	50	60	10	20	60	30
Zinc, dissolved	3	32	31	1	2	34	30
OXYGEN DEMAND							
Oxygen demand, chemical, 0.25 N dichromate (mg/L)	15	14	12	2	6	30	<7
ORGANICS							
Carbon, organic, dissolved (mg/L as C)	13	3.6	3.3	0.4	1.4	6.2	2.1
Phenols, total recoverable (µg/L)	11	8	8	2	6	25	1
Pesticides (total recoverable, µg/L)							
Chlordane	20	0.12	<0.10	0.02	0.07	0.40	<0.10
Diazinon	20	0.12	0.08	0.02	0.11	0.42	0.02
Endosulfan	20	0.01	<0.01	0.00	0.01	0.04	<0.01
Lindane	20	0.01	0.01	0.00	0.00	0.02	<0.01
Malathion	20	0.03	0.03	0.01	0.03	0.11	<0.01
Methoxychlor	20	0.01	<0.01	0.00	0.01	0.05	<0.01
Parathion	20	0.23	0.20	0.06	0.26	0.86	<0.01
2,4-D	20	0.02	<0.01	0.00	0.01	0.04	<0.01

Table 7. Statistical summary of rainfall quality data: Single-dwelling residential site—Continued

Other pesticides analyzed but not detected

Pesticide (total recoverable)	Detection limit (µg/L)	Number of samples	Pesticide (total recoverable)	Detection limit (µg/L)	Number of samples
Aldrin	0.01	20	Methomyl	2	5
DDD	0.01	20	Methyl parathion	0.01	*20
DDE	0.01	**20	Methyl trithion	0.01	20
DDT	0.01	20	Mirex	0.01	20
Dieldrin	0.01	*20	Perthane	0.1	20
Endrin	0.01	20	Propham	2	5
Ethion	0.01	20	Sevin	2	5
Gross polychlorinated biphenyls	0.1	20	Silvex	0.01	20
Gross polychlorinated naphthalenes	0.1	20	Toxaphene	1	20
Heptachlor	0.01	20	Trithion	0.01	20
Heptachlor epoxide	0.01	20	2,4-DP	0.01	20
			2,4,5-T	0.01	20

*One sample was equal to the detection limit.
**Three samples were equal to the detection limit.

Table 8. Statistical summary of rainfall quality data: Laboratory site

[Statistical calculations include analytical detection limit concentration for those analyses which are reported to be less than detection limit. Other pesticides were analyzed for but not detected and are given at the end of this table. ., no data available. <, actual value is less than value shown]

Property or constituent	Number of samples	Mean	Median	Standard error of mean	Standard deviation	Maximum	Minimum
INORGANICS							
Field measurements							
Specific conductance (µS/cm at 25°C)	16	12	11	2	8	30	4
pH (units)	16	6.0	6.1	0.2	0.8	7.4	4.7
Major ions (mg/L)							
Calcium, dissolved	3	0.47	0.25	0.23	0.39	0.92	0.23
Magnesium, dissolved	3	0.06	0.07	0.02	0.03	0.08	<0.02
Sodium, dissolved	3	0.4	0.4	0.2	0.2	0.7	0.2
Potassium, dissolved	3	0.2	0.2	0.0	0.1	0.3	0.2
Alkalinity, total as ($CaCO_3$)	3	6	7	1	1	7	5
Sulfate, dissolved	3	1.2	1.1	0.1	0.2	1.4	1.1
Chloride, dissolved	3	0.6	0.3	0.3	0.5	1.2	0.3
Silica, dissolved	0	.	.	.	.	.	.
Nutrients (mg/L)							
Nitrogen, nitrite, dissolved (as N)	7	0.02	0.02	0.00	0.01	0.05	<0.02
Nitrogen, nitrite plus nitrate, dissolved (as N)	8	0.23	0.15	0.07	0.19	0.56	<0.10
Nitrogen, ammonia, dissolved (as N)	7	0.46	0.43	0.06	0.16	0.76	0.27
Nitrogen, ammonia plus organic, dissolved (as N)	8	1.0	0.8	0.19	0.53	2.1	0.60
Nitrogen, organic, dissolved (as N)	4	0.49	0.56	0.14	0.27	0.74	0.12
Nitrogen, dissolved (as N)	6	1.3	1.1	0.30	0.73	2.6	0.74
Phosphorus, dissolved (as N)	7	0.02	0.01	0.00	0.01	0.04	<0.01
Phosphorus, orthophosphate, dissolved (as P)	8	0.02	0.02	0.01	0.02	0.07	<0.01

Table 8. Statistical summary of rainfall quality data: Laboratory site—Continued

Property or constituent	Number of samples	Mean	Median	Standard error of mean	Standard deviation	Maximum	Minimum
INORGANICS--Continued							
Metals (µg/L)							
Aluminum, total recoverable	3	80	80	9	20	90	60
Aluminum, dissolved	3	10	<10	3	6	20	<10
Arsenic, total	5	1	<1	0	0	1	<1
Chromium, total recoverable	3	1	<1	0	0	<1	<1
Copper, total recoverable	3	4	2	2	3	8	<2
Copper, dissolved	3	1	1	0	1	2	1
Iron, total recoverable	6	460	80	250	610	1,300	40
Iron, dissolved	6	12	10	4	10	30	<3
Lead, total recoverable	6	11	5	7	16	44	2
Lead, dissolved	6	2	1	1	2	6	<1
Manganese, total recoverable	6	20	10	0	10	40	<10
Manganese, dissolved	6	6	7	2	4	10	1
Mercury, total recoverable	5	0.1	<0.1	0.0	0.0	0.1	<0.1
Nickel, total recoverable	6	5	5	1	3	9	2
Nickel, dissolved	6	2	3	0	1	4	1
Zinc, total recoverable	3	20	20	0	10	30	20
Zinc, dissolved	3	19	17	4	6	26	14
OXYGEN DEMAND							
Oxygen demand, chemical, 0.25 N dichromate (mg/L)	5	16	16	2	5	23	<10
ORGANICS							
Carbon, organic, dissolved (mg/L as C)	7	6.9	5.9	1.7	4.4	16.0	1.8
Phenols, total recoverable (µg/L)	10	7	6	1	4	14	2
Pesticides (total recoverable, µg/L)							
Chlordane	10	0.10	<0.10	0.00	0.00	<0.10	<0.10
DDE	10	0.01	<0.01	0.00	0.00	0.02	<0.01
Diazinon	13	0.13	0.11	0.02	0.07	0.26	0.03
Endosulfan	10	0.02	<0.01	0.01	0.02	0.07	<0.01
Lindane	10	0.01	0.01	0.00	0.00	0.01	<0.01
Malathion	13	0.04	0.03	0.01	0.03	0.10	0.01
Methoxychlor	10	0.01	<0.01	0.00	0.01	0.04	<0.01
Parathion	13	0.19	0.16	0.05	0.19	0.66	<0.01
2,4-D	9	0.01	<0.01	0.00	0.01	0.04	<0.01

Other pesticides analyzed but not detected

Pesticide (total recoverable)	Detection limit (µg/L)	Number of samples	Pesticide (total recoverable)	Detection limit (µg/L)	Number of samples
Aldrin	0.01	10	Heptachlor epoxide	0.01	10
DDD	0.01	10	Methyl parathion	0.01	*13
DDT	0.01	10	Methyl trithion	0.01	13
Dieldrin	0.01	*10	Mirex	0.01	10
Endrin	0.01	10	Perthane	0.1	10
Ethion	0.01	*13	Silvex	0.01	9
Gross polychlorinated biphenyls	0.1	10	Toxaphene	1	10
Gross polychlorinated naphthalenes	0.1	10	Trithion	0.01	13
Heptachlor	0.01	10	2,4-DP	0.01	9
			2,4,5-T	0.01	9

*One sample was equal to the detection limit.

Table 9. Results of statistical comparison testing between sites for composite rainfall quality samples

[Comparison testing includes only those constituents that were consistently above analytical detection levels. 1, statistically similar at 0.05-significance level; 2, statistically different at 0.05-significance level; 3, no test performed due to significant difference between years for these constituents at the industrial site; 4, no test performed (no silica data for laboratory site)]

Property or constituent	Sites compared		
	Industrial/ Single	Industrial/ Laboratory	Single/ Laboratory
pH	2	1	1
Specific conductance	1	1	1
Calcium, dissolved	1	1	1
Magnesium, dissolved	1	1	1
Sodium, dissolved	1	1	1
Potassium, dissolved	2	1	2
Sulfate, dissolved	1	1	1
Chloride, dissolved	1	1	1
Silica, dissolved	1	4	4
Nitrogen, nitrite, dissolved (as N)	1	1	1
Nitrogen, nitrite plus nitrate, dissolved (as N)	1	1	1
Nitrogen, ammonia, dissolved (as N)	2	1	1
Nitrogen, ammonia plus organic, dissolved (as N)	2	1	1
Phosphorus, dissolved (as P)	3	3	1
Aluminum, total recoverable	1	1	1
Copper, total recoverable	1	1	1
Iron, total recoverable	1	1	1
Lead, total recoverable	1	1	1
Lead, dissolved	1	1	1
Manganese, total recoverable	1	1	1
Manganese, dissolved	1	1	1
Nickel, total recoverable	1	1	1
Zinc, total recoverable	1	1	1
Zinc, dissolved	1	1	2
Oxygen demand, chemical, 0.25 N dichromate	1	1	1
Carbon, organic, dissolved	3	3	2
Phenols, total recoverable	2	1	1

Table 10. Rainfall constituent event mean concentrations and loads for storms monitored at industrial site

[Event mean concentrations, in milligrams per liter (mg/L) or micrograms per liter (μg/L); storm load, in pounds (lb). ., no data available. <, actual value is less than value shown]

Storm beginning date	Storm ending date	Rainfall total (in.)	Nitrogen, nitrite plus nitrate, dissolved		Nitrogen, ammonia plus organic, dissolved		Phosphorus, dissolved		Oxygen demand, chemical, 0.25 N dichromate		Carbon, organic, dissolved	
			mg/L	lb	mg/L	lb	mg/L	lb	mg/L	lb	mg/L	lb
12-29-81	12-29-81	0.18	0.16	1.8	0.90	10	0.08	0.91	18	204	3.1	35
01-04-82	01-04-82	0.62	<0.09	<3.5	0.59	23	0.05	2.0	<12	<469	5.2	203
02-14-82	02-16-82	0.53	0.23	7.7	4.0	134	0.09	3.0	12	401	5.7	190
03-09-82	03-10-82	0.33	0.37	7.7	.	.	0.18	3.7	19	395	3.3	69
03-10-82	02-11-82	0.20	0.31	3.9	1.6	20	0.13	1.6	22	277	6.2	78
03-25-82	03-26-82	0.24	0.43	6.5	1.7	25	0.13	2.0	26	393	4.0	60
03-28-82	03-29-82	1.02	0.11	7.1	0.87	56	0.04	2.6	15	964	4.6	296
09-24-82	09-24-82	0.20	0.96	12	3.2	40	0.28	3.5	.	.	.	.
10-25-82	10-25-82	0.19	.	.	.	.	.	.	.	.	.	.
10-26-82	10-26-82	0.59	0.13	5.8	1.1	41	0.06	2.2	27	1,004	4.5	167
11-09-82	11-09-82	0.45	<0.10	<2.8	1.3	37	0.01	0.28	<10	<283	2.7	77
01-18-83	01-19-83	0.78	<0.10	<4.9	1.2	59	0.03	1.5	<10	<491	2.7	133
01-23-83	01-24-83	0.70	0.10	4.4	1.1	48	0.01	0.44	<10	<441	4.0	176

Storm beginning date	Storm ending date	Rainfall total (in.)	Aluminum, total recoverable		Arsenic, total		Chromium, total recoverable		Copper, total recoverable		Iron, total recoverable	
			μg/L	lb	μg/L	lb	μg/L	lb	μg/L	lb	μg/L	lb
12-29-81	12-29-81	0.18	.	.	.	.	.	.	.	.	.	.
01-04-82	01-04-82	0.62	.	.	.	.	.	.	.	.	.	.
02-14-82	02-16-82	0.53	.	.	.	.	.	.	.	.	.	.
03-09-82	03-10-82	0.33	.	.	.	.	.	.	.	.	.	.
03-10-82	03-11-82	0.20	.	.	.	.	.	.	.	.	.	.
03-25-82	03-26-82	0.24	.	.	.	.	.	.	.	.	.	.
03-28-82	03-29-82	1.02	.	.	.	.	.	.	.	.	.	.
09-24-82	09-24-82	0.20	.	.	.	.	.	.	.	.	2,800	35
10-25-82	10-25-82	0.19	580	6.9	.	.	1	0.01	12	0.14	830	9.9
10-26-82	10-26-82	0.59	.	.	<1	<0.04	.	.	.	.	40	1.5
11-09-82	11-09-82	0.45	140	4.0	<1	<0.03	<1	<0.03	6	0.17	350	9.9
01-18-83	01-19-83	0.78	60	3.0	<1	<0.05	<1	<0.05	6	0.30	60	3.0
01-23-83	01-04-83	0.70	.	.	<1	<0.04	.	.	.	.	10	0.44

Storm beginning date	Storm ending date	Rainfall total (in.)	Lead, total recoverable		Manganese, total recoverable		Mercury, total recoverable		Nickel, total recoverable		Zinc, total recoverable	
			μg/L	lb	μg/L	lb	μg/L	lb	μg/L	lb	μg/L	lb
12-29-81	12-29-81	0.18	.	.	.	.	.	.	.	.	.	.
01-04-82	01-04-82	0.62	7	0.27	.	.	.	.	.	.	.	.
02-14-82	02-16-82	0.53	20	0.67	.	.	.	.	.	.	.	.
03-09-82	03-10-82	0.33	8	0.17	.	.	.	.	.	.	.	.
03-10-82	03-11-82	0.20	5	0.06	.	.	.	.	.	.	.	.
03-25-82	03-26-82	0.24	13	0.20	.	.	.	.	.	.	.	.
03-28-82	03-29-82	1.02	10	0.64	.	.	.	.	.	.	.	.
09-24-82	09-24-82	0.20	51	0.64	80	1.0	.	.	11	0.14	.	.
10-25-82	10-25-82	0.19	16	0.19	40	0.48	.	.	3	0.04	90	1.1
10-26-82	10-26-82	0.59	4	0.15	<10	<0.37	<0.1	<0.01	5	0.19	.	.
11-09-82	11-09-82	0.45	8	0.23	10	0.28	0.1	<0.01	10	0.28	70	2.0
01-18-83	01-19-83	0.78	2	0.10	<10	<0.49	0.2	0.01	<1	<0.05	40	2.0
01-23-83	01-24-83	0.70	2	0.09	<10	<0.44	<0.1	<0.01	1	0.04	.	.

Table 11. Rainfall constituent event mean concentrations and loads for storms monitored at single-dwelling residential site

[Event mean concentrations, in milligrams per liter (mg/L) or micrograms per liter (μg/L); storm load, in pounds (lb). ., no data available. <, actual value is less than value shown]

Storm beginning date	Storm ending date	Rainfall total (in.)	Nitrogen, nitrite plus nitrate, dissolved		Nitrogen, ammonia plus organic, dissolved		Phosphorus, dissolved		Oxygen demand, chemical, 0.25 N dichromate		Carbon, organic, dissolved	
			mg/L	lb	mg/L	lb	mg/L	lb	mg/L	lb	mg/L	lb
12-29-81	12-30-81	0.38	0.14	1.1	0.68	5.5	0.02	0.16	16	130	3.2	26
01-04-82	01-04-82	0.83	<0.09	<1.6	0.53	9.4	0.01	0.18	<12	<212	2.1	37
02-14-82	02-16-82	0.65	0.17	2.4	1.7	24	0.08	1.1	<7	<97	5.5	76
03-09-82	03-10-82	0.47	0.46	4.6	.	.	<0.01	<0.10	<12	<120	2.4	24
03-10-82	03-11-82	0.30	0.25	1.6	9.7	62	0.01	0.06	20	128	5.1	33
03-25-82	03-26-82	0.20	0.45	1.9	1.3	5.5	0.04	0.17	30	128	6.2	26
03-28-82	03-29-82	0.45	0.17	1.6	0.92	8.8	<0.01	<0.10	11	105	3.5	34
03-31-82	03-31-82	0.95	0.04	0.81	0.36	7.3	<0.01	<0.20	12	243	.	.
09-24-82	09-24-82	0.22	0.60	2.8	.	.	0.14	0.66	.	.	.	.
10-25-82	10-25-82	0.09	.	.	.	.	.	.	.	.	.	.
10-26-82	10-26-82	0.69	0.10	1.5	1.0	15	<0.01	<0.15	<10	<147	2.3	34
11-09-82	11-09-82	0.45	0.12	1.2	0.90	8.6	0.01	0.10	13	125	4.9	47
01-18-83	01-19-83	0.85	<0.10	<1.8	0.70	13	0.02	0.36	17	308	.	.
01-24-83	01-24-83	0.74	<0.10	<1.6	0.30	4.7	0.01	0.16	10	158	2.1	33
02-28-83	03-01-83	1.1	<0.10	<2.4	0.50	12	0.01	0.24	<10	<236	2.4	57
03-16-83	03-16-83	0.40	0.46	3.9	0.70	6.0	0.03	0.26	20	170	3.3	28
03-23-83	03-23-83	0.57	0.10	1.2	0.60	7.3	0.01	0.12	17	206	3.9	47

Storm beginning date	Storm ending date	Rainfall total (in.)	Aluminum, total recoverable		Arsenic, total		Chromium, total recoverable		Copper, total recoverable		Iron, total recoverable	
			μg/L	lb	μg/L	lb	μg/L	lb	μg/L	lb	μg/L	lb
12-29-81	12-30-81	0.38	.	.	.	.	.	.	.	.	.	.
01-04-82	01-04-82	0.83	.	.	.	.	.	.	.	.	.	.
02-14-82	02-16-82	0.65	.	.	.	.	.	.	.	.	.	.
03-09-82	03-10-82	0.47	.	.	.	.	.	.	.	.	.	.
03-10-82	03-11-82	0.30	.	.	.	.	.	.	.	.	.	.
03-25-82	03-26-82	0.20	.	.	.	.	.	.	.	.	.	.
03-28-82	03-29-82	0.45	.	.	.	.	.	.	.	.	.	.
03-31-82	03-31-82	0.95	.	.	.	.	.	.	.	.	.	.
09-24-82	09-24-82	0.22	.	.	.	.	.	.	.	.	770	3.6
10-25-82	10-25-82	0.09	.	.	.	.	.	.	.	.	1,400	2.7
10-26-82	10-26-82	0.69	.	.	<1	<0.02	.	.	.	.	90	1.3
11-09-82	11-09-82	0.45	30	0.29	<1	<0.01	<1	<0.01	4	0.04	360	3.4
01-18-83	01-19-83	0.85	80	1.4	<1	<0.02	<1	<0.02	6	0.11	90	1.6
01-24-83	01-24-83	0.74	.	.	<1	<0.02	.	.	.	.	40	0.63
02-28-83	03-01-83	1.1	50	1.2	<1	<0.02	<1	<0.02	1	0.02	10	0.24
03-16-83	03-16-83	0.40	.	.	<1	<0.01	.	.	.	.	170	1.4
03-23-83	03-23-83	0.57	.	.	<1	<0.01	.	.	.	.	60	0.73

Table 11. Rainfall constituent event mean concentrations and loads for storms monitored at single-dwelling residential site—Continued

Storm beginning date	Storm ending date	Rainfall total (in.)	Lead, total recoverable		Manganese, total recoverable		Mercury, total recoverable		Nickel, total recoverable		Zinc, total recoverable	
			µg/L	lb	µg/L	lb	µg/L	lb	µg/L	lb	µg/L	lb
12-29-81	12-30-81	0.38	.	.	.	.	.	.	.	.	.	.
01-04-82	01-04-82	0.83	3	0.05	.	.	.	.	.	.	.	.
02-14-82	02-16-82	0.65	15	0.21	.	.	.	.	.	.	.	.
03-09-82	03-10-82	0.47	8	0.08	.	.	.	.	.	.	.	.
03-10-82	03-11-82	0.30	10	0.06	.	.	.	.	.	.	.	.
03-25-82	03-26-82	0.20	25	0.11	.	.	.	.	.	.	.	.
03-28-82	03-29-82	0.45	9	0.09	.	.	.	.	.	.	.	.
03-31-82	03-31-82	0.95	<4	<0.08	.	.	.	.	.	.	.	.
09-24-82	09-24-82	0.22	15	0.07	30	0.14	.	.	5	0.02	.	.
10-25-82	10-25-82	0.09	61	0.12	60	0.12	.	.	12	0.02	.	.
10-26-82	10-26-82	0.69	4	0.06	10	0.15	0.1	<0.01	9	0.13	.	.
11-09-82	11-09-82	0.45	5	0.05	10	0.10	0.1	<0.01	5	0.05	60	0.58
01-18-83	01-19-83	0.85	4	0.07	<10	<0.18	0.1	<0.01	<1	<0.02	60	1.1
01-24-83	01-24-83	0.74	4	0.06	<10	<0.16	<0.1	<0.01	10	0.16	.	.
02-28-83	03-01-83	1.1	<1	<0.02	<10	<0.24	0.1	<0.01	4	0.10	30	0.71
03-16-83	03-16-83	0.40	12	0.10	10	0.08	0.1	<0.01	10	0.08	.	.
03-23-83	03-23-83	0.57	8	0.10	<10	<0.12	<0.1	<0.01	4	0.05	.	.

Table 12. Statistical summary of discrete runoff sample data: Industrial catchment

[Statistical calculations include analytical detection limit concentration for those analyses which are reported to be less than detection limit. Other organics were analyzed for but not detected and are given at the end of this table. <, actual value is less than value shown]

Property or constituent	Number of samples	Mean	Median	Standard error of mean	Standard deviation	Maximum	Minimum
INORGANICS							
Field measurements							
Specific conductance (µS/cm at 25°C)	285	464	304	42	704	9,960	96
pH (units)	221	6.7	6.7	0.0	0.3	7.5	4.9
Major ions (mg/L)							
Hardness, total (as $CaCO_3$)	101	65	48	5	52	410	17
Calcium, dissolved	101	15	11	1.4	14	120	4.0
Magnesium, dissolved	101	6.4	4.9	0.5	4.6	26	1.6
Sodium, dissolved	102	74	19	19	200	1,800	5.7
Potassium, dissolved	99	24	22	1.1	11	62	5.2
Alkalinity, total (as $CaCO_3$)	101	84	79	5	47	221	5
Sulfate, dissolved	102	25	16	2.0	21	110	<5.0
Chloride, dissolved	102	110	24	32	320	3,000	4.8
Silica, dissolved	74	5.4	4.0	0.6	5.0	30	1.6
Nutrients (mg/L)							
Nitrogen, nitrate, dissolved (as N)	42	1.2	1.0	0.13	0.83	3.3	0.00
Nitrogen, nitrite plus nitrate, dissolved (as N)	81	1.8	1.3	0.14	1.3	5.5	0.10
Nitrogen, ammonia, dissolved (as N)	86	6.6	6.4	0.35	3.2	20	0.90
Nitrogen, ammonia plus organic, total (as N)	78	27	24	1.4	13	78	8.8
Nitrogen, ammonia plus organic, dissolved (as N)	83	18	17	0.93	8.5	45	3.6
Nitrogen, organic, dissolved (as N)	86	12	10	0.79	7.3	38	0.1
Nitrogen, dissolved (as N)	79	20	18	1.2	10	54	4.0
Phosphorus, total (as P)	90	6.6	6.3	0.29	2.8	20	0.92
Phosphorus, dissolved (as P)	89	5.0	4.7	0.25	2.4	11	0.40
Phosphorus, orthophosphate, total (as P)	71	4.5	4.0	0.25	2.1	10	0.72
Phosphorus, orthophosphate, dissolved (as P)	66	3.7	3.3	0.23	1.8	9	0.68
Metals (µg/L)							
Aluminum, total recoverable	16	10,000	7,000	1,300	5,300	18,000	3,000
Aluminum, dissolved	16	160	150	21	82	290	20
Arsenic, total	107	17	14	1	11	67	1
Arsenic, dissolved	68	10	9	1	7	50	1
Cadmium, total recoverable	70	2	1	0	1	4	<1
Cadmium, dissolved	69	2	<1	0	1	6	<1
Chromium, total recoverable	86	17	14	1	13	51	<1
Chromium, dissolved	69	2	<1	0	2	13	<1
Copper, total recoverable	86	89	66	7	67	400	30
Copper, dissolved	85	16	15	1	9	40	3
Iron, total recoverable	107	12,000	9,000	980	10,000	62,000	480
Iron, dissolved	102	620	370	83	840	7,400	22
Lead, total recoverable	107	95	74	7	75	360	16
Lead, dissolved	106	10	9	1	7	39	<1
Manganese, total recoverable	37	520	360	57	350	1,600	170
Manganese, dissolved	37	180	130	26	160	750	46
Mercury, total recoverable	107	0.2	0.1	0.0	0.3	2.5	<0.1
Mercury, dissolved	69	0.2	0.1	0.0	0.2	1.8	<0.1
Nickel, total recoverable	107	27	24	2	17	98	4
Nickel, dissolved	106	9	8	0	6	30	<1
Zinc, total recoverable	86	740	535	62	580	3,100	280
Zinc, dissolved	81	250	190	22	200	1,400	70
BIOLOGICAL							
Coliform, fecal, 0.7 µm-MF (colonies/100 mL)	20	9,700	4,250	2,300	10,000	31,000	<120

Table 12. Statistical summary of discrete runoff sample data: Industrial catchment—Continued

Property or constituent	Number of samples	Mean	Median	Standard error of mean	Standard deviation	Maximum	Minimum
OXYGEN DEMAND (mg/L)							
Oxygen demand, chemical, 0.25 N dichromate	56	620	490	56	417	2,500	150
Oxygen demand, biochemical, carbonaceous, 5-day at 20°C	42	149	135	11	70	330	30
Oxygen demand, biochemical, carbonaceous, 20-day	42	189	160	20	126	830	39
PHYSICAL PROPERTIES							
Turbidity (NTU)	83	160	110	15	141	800	1
Solids, residue at 180°C, dissolved (mg/L)	93	423	242	67	648	5,870	77
Solids, sum of constituents, dissolved (mg/L)	96	321	165	56	545	4,997	63
Sediment, suspended (mg/L)	100	684	500	62	619	2,770	51
ORGANICS							
Carbon, organic, dissolved (mg/L as C)	56	190	130	42	310	2,300	20
Carbon, organic, suspended (mg/L as C)	54	25	26	1.5	11	41	5.8
Cyanide, total (mg/L)	3	0.01	<0.01	0.00	0.00	<0.01	<0.01
Cyanide, dissolved (mg/L)	3	0.01	<0.01	0.00	0.00	<0.01	<0.01
Oil and grease, total recoverable, gravimetric (mg/L)	15	11	4	5	20	80	<1
Phenols, total recoverable (µg/L)	5	114	20	96	216	500	8
Pesticides (total recoverable, µg/L)							
Chlordane	19	0.12	<0.10	0.01	0.05	0.30	<0.10
DDE	19	0.01	0.01	0.00	0.01	0.03	<0.01
Diazinon	18	0.67	0.53	0.17	0.71	3.3	0.14
Dieldrin	19	0.01	<0.01	0.00	0.00	0.02	<0.01
Endosulfan	19	0.01	<0.01	0.00	0.00	0.02	<0.01
Lindane	19	0.05	0.03	0.01	0.06	0.27	0.01
Malathion	18	0.66	0.44	0.16	0.67	3.0	0.20
Methoxychlor	19	0.01	<0.01	0.00	0.00	0.03	<0.01
Parathion	18	0.05	<0.01	0.02	0.09	0.38	<0.01
Silvex	19	0.01	<0.01	0.00	0.01	0.07	<0.01
2,4-D	19	0.26	0.03	0.17	0.72	3.2	<0.01

Other organics analyzed but not detected

Organic (total recoverable)	Detection limit (µg/L)	Number of samples	Organic (total recoverable)	Detection limit (µg/L)	Number of samples
Aldrin	0.01	19	Heptachlor	0.01	19
Benzene	1	5	Heptachlor epoxide	0.01	19
Chlorobenzene	1	5	Methomyl	2	8
DDD	0.01	19	Methyl parathion	0.01	18
DDT	0.01	19	Methyl trithion	0.01	19
Dibromochloropropane	0.003	*7	Mirex	0.01	19
Endrin	0.01	19	Perthane	0.1	19
Ethion	0.01	19	Propham	2	8
Ethylbenzene	1	5	Sevin	2	8
Gross polychlorinated biphenyls	0.1	19	Toxaphene	1	19
			Trithion	0.01	19
Gross polychlorinated naphthalenes	0.1	19	2,4-DP	0.01	19
			2,4,5-T	0.01	19

*One sample had a concentration equal to the detection limit.

Table 13. Statistical summary of discrete runoff sample data: Single-dwelling residential catchment

[Statistical calculations include analytical detection limit concentration for those analyses which are reported to be less than detection limit. Other organics were analyzed for but not detected and are given at the end of this table. <, actual value is less than value shown]

Property or constituent	Number of samples	Mean	Median	Standard error of mean	Standard deviation	Maximum	Minimum
INORGANICS							
Field measurements							
Specific conductance (µS/cm at 25°C)	121	56	40	4	44	222	15
pH (units)	97	7.1	7.0	0.0	0.4	8.3	6.5
Major ions (mg/L)							
Hardness, total (as $CaCO_3$)	62	20	15	2	16	70	4
Calcium, dissolved	65	5.8	4.7	0.5	4.1	18	1.3
Magnesium, dissolved	65	1.3	0.7	0.2	1.4	6.2	0.1
Sodium, dissolved	65	3.9	3.2	0.4	3.0	18	0.7
Potassium, dissolved	65	3	2.3	0.3	2.4	9.8	0.8
Alkalinity, total (as $CaCO_3$)	65	19	15	2	14	73	7
Sulfate, dissolved	61	8	7	1	4	27	4
Chloride, dissolved	64	3.3	2.5	0.4	3.1	14	0.6
Silica, dissolved	44	3.0	2.2	0.6	4.0	27	0.8
Nutrients (mg/L)							
Nitrogen, nitrate, dissolved (as N)	25	0.75	0.49	0.12	0.58	2.1	0.18
Nitrogen, nitrite plus nitrate, dissolved (as N)	65	0.93	0.50	0.13	1.0	4.7	0.11
Nitrogen, ammonia, dissolved (as N)	65	1.4	0.6	0.18	1.5	6.4	0.12
Nitrogen, ammonia plus organic, total (as N)	55	4.5	2.7	0.61	4.5	22	0.57
Nitrogen, ammonia plus organic, dissolved (as N)	64	3.8	2.1	0.5	3.8	16	0.5
Nitrogen, organic, dissolved (as N)	62	2.6	1.5	0.3	2.7	12	0.2
Nitrogen, dissolved (as N)	64	4.8	2.4	0.60	4.8	21	0.63
Phosphorus, total (as P)	65	0.63	0.39	0.07	0.59	2.4	0.10
Phosphorus, dissolved (as P)	65	0.37	0.23	0.04	0.32	1.6	0.09
Phosphorus, orthophosphate, total (as P)	64	0.37	0.22	0.05	0.38	2.2	0.10
Phosphorus, orthophosphate, dissolved (as P)	64	0.31	0.20	0.04	0.29	1.6	0.09
Metals (µg/L)							
Aluminum, total recoverable	17	5,000	3,400	1,300	5,400	20,000	530
Aluminum, dissolved	17	100	50	30	110	370	30
Arsenic, total	64	2	1	0	2	8	<1
Arsenic, dissolved	31	1	1	0	1	5	<1
Cadmium, total recoverable	31	1	1	0	1	4	<1
Cadmium, dissolved	31	2	2	0	1	4	<1
Chromium, total recoverable	48	9	8	1	7	40	<1
Chromium, dissolved	31	1	<1	0	1	4	<1
Copper, total recoverable	47	32	14	6	40	180	4
Copper, dissolved	48	6	5	1	4	21	<1
Iron, total recoverable	64	4,600	1,700	790	6,300	29,000	160
Iron, dissolved	64	190	91	28	230	960	29
Lead, total recoverable	63	350	170	53	420	2,100	15
Lead, dissolved	64	42	25	5	41	200	2
Manganese, total recoverable	32	160	110	30	150	480	20
Manganese, dissolved	33	50	23	10	60	210	5
Mercury, total recoverable	64	0.6	0.1	0.2	1.4	8.6	<0.1
Mercury, dissolved	31	0.1	<0.1	0.0	0.0	0.1	<0.1
Nickel, total recoverable	62	19	11	3	22	85	1
Nickel, dissolved	64	6	4	1	7	30	<1
Zinc, total recoverable	47	210	90	40	280	1,300	30
Zinc, dissolved	48	70	43	10	71	350	21
BIOLOGICAL							
Coliform, fecal, 0.7 µm-MF (colonies/100 mL)	12	23,000	8,100	14,000	50,000	180,000	<1,000

Table 13. Statistical summary of discrete runoff sample data: Single-dwelling residential catchment—Continued

Property or constituent	Number of samples	Mean	Median	Standard error of mean	Standard deviation	Maximum	Minimum
OXYGEN DEMAND (mg/L)							
Oxygen demand, chemical, 0.25 N dichromate	34	106	95	10	56	290	27
Oxygen demand, biochemical, carbonaceous, 5-day at 20°C	22	14.6	8.3	3.4	16	53	2.1
Oxygen demand, biochemical, carbonaceous, 20-day	22	21	12	4.7	22	81	2.3
PHYSICAL PROPERTIES							
Turbidity (NTU)	49	57	11	20	138	900	1.7
Solids, residue at 180°C, dissolved (mg/L)	64	63	46	6	48	224	9
Solids, sum of constituents, dissolved (mg/L)	64	45	34	4	31	155	13
Sediment, suspended (mg/L)	64	246	70	48	380	1,540	9
ORGANICS							
Carbon, organic, dissolved (mg/L as C)	36	75	46	16	96	550	4
Carbon, organic, suspended (mg/L as C)	33	3.2	2.3	0.6	3.2	17	0.8
Cyanide, total (mg/L)	5	0.01	<0.01	0.00	0.00	<0.01	<0.01
Cyanide, dissolved (mg/L)	5	0.01	<0.01	0.00	0.00	<0.01	<0.01
Oil and grease, total recoverable, gravimetric (mg/L)	11	3	2	1	2	8	1
Phenols, total recoverable (µg/L)	5	22	18	4	10	35	13
Pesticides (total recoverable, µg/L)							
Chlordane	16	0.16	0.10	0.02	0.07	0.30	0.10
Diazinon	16	0.36	0.27	0.07	0.27	1.1	0.11
Lindane	16	0.03	0.03	0.00	0.02	0.06	0.01
Malathion	16	2.2	0.99	0.82	3.3	13	0.19
Methoxychlor	16	0.03	<0.01	0.01	0.05	0.19	<0.01
Methyl parathion	16	0.01	<0.01	0.00	0.00	0.03	<0.01
Parathion	16	0.21	0.13	0.07	0.26	0.92	<0.01
Silvex	16	0.01	<0.01	0.00	0.00	0.03	<0.01
2,4-D	16	0.26	0.07	0.13	0.51	1.7	<0.01

Other organics analyzed but not detected

Organic (total recoverable)	Detection limit (µg/L)	Number of samples	Organic (total recoverable)	Detection limit (µg/L)	Number of samples
Aldrin	0.01	16	Heptachlor	0.01	16
Benzene	1	3	Heptachlor epoxide	0.01	16
Chlorobenzene	1	3	Methomyl	2	4
DDD	0.01	16	Methyl trithion	0.01	16
DDE	0.01	*16	Mirex	0.01	16
DDT	0.01	**16	Perthane	0.01	16
Dibromochloropropane	0.003	**4	Propham	0.01	4
Dieldrin	0.01	*16	Sevin	2	4
Endosulfan	0.01	**16	Silvex	0.01	16
Endrin	0.01	**16	Toxaphene	0.1	16
Ethion	0.01	16	Trithion	2	16
Ethylbenzene	1	3	2,4-DP	2	16
Gross polychlorinated biphenyls	0.1	16	2,4,5-T	0.01	16
Gross polychlorinated naphthalenes	0.1	16			

*Four samples had concentrations equal to the detection limit.

**One sample had a concentration equal to the detection limit.

Table 14. Statistical summary of discrete runoff sample data: Multiple-dwelling residential catchment

[Statistical calculations include analytical detection limit concentration for those analyses which are reported to be less than detection limit. Other organics were analyzed for but not detected and are given at the end of this table. <, actual value is less than value shown]

Property or constituent	Number of samples	Mean	Median	Standard error of mean	Standard deviation	Maximum	Minimum
INORGANICS							
Field measurements							
Specific conductance (µS/cm at 25°C)	230	66	44	5	70	606	17
pH (units)	169	7.1	7.0	0.0	0.3	8.8	6.4
Major ions (mg/L)							
Hardness, total (as $CaCO_3$)	85	30	14	4	37	230	6
Calcium, dissolved	87	8.3	4.3	1.1	10	65	2.0
Magnesium, dissolved	87	2.1	0.9	0.3	2.8	16	0.3
Sodium, dissolved	87	6.8	3.8	0.9	8.5	49	1.0
Potassium, dissolved	87	3.4	2.2	0.3	3.2	19	0.8
Alkalinity, total (as $CaCO_3$)	89	25	15	2	24	150	6
Sulfate, dissolved	88	12	8.0	1.3	12	76	3.6
Chloride, dissolved	88	5.1	2.0	0.9	8.8	65	0.6
Silica, dissolved	68	4.7	2.8	0.6	5.4	25	1.5
Nutrients (mg/L)							
Nitrogen, nitrate, dissolved (as N)	45	0.89	0.53	0.19	1.2	6.6	0.14
Nitrogen, nitrite plus nitrate, dissolved (as N)	88	1.1	0.60	0.16	1.5	7.5	<0.10
Nitrogen, ammonia, dissolved (as N)	88	1.4	0.94	0.15	1.4	7.3	<0.06
Nitrogen, ammonia plus organic, total (as N)	85	5.2	2.7	0.64	5.9	25	0.83
Nitrogen, ammonia plus organic, dissolved (as N)	88	4.3	2.5	0.5	5.0	26	<0.2
Nitrogen, organic, dissolved (as N)	84	2.9	1.3	0.5	4.2	25	0.2
Nitrogen, dissolved (as N)	86	5.5	3.4	0.71	6.6	33	0.82
Phosphorus, total (as P)	89	0.81	0.43	0.10	0.97	5.0	0.08
Phosphorus, dissolved (as P)	87	0.58	0.30	0.08	0.77	4.7	0.06
Phosphorus, orthophosphate, total (as P)	87	0.46	0.27	0.05	0.46	2.4	0.07
Phosphorus, orthophosphate, dissolved (as P)	88	0.38	0.22	0.04	0.39	2.1	0.03
Metals (µg/L)							
Aluminum, total recoverable	17	12,000	6,300	2,800	11,000	37,000	1,600
Aluminum, dissolved	14	250	195	50	170	570	50
Arsenic, total	87	3	2	0	3	16	<1
Arsenic, dissolved	51	2	1	0	2	10	<1
Cadmium, total recoverable	53	2	1	0	1	6	<1
Cadmium, dissolved	51	2	<1	0	1	5	<1
Chromium, total recoverable	70	16	15	1	10	62	1
Chromium, dissolved	51	1	<1	0	1	4	<1
Copper, total recoverable	70	39	22	6	49	270	7
Copper, dissolved	66	9	5	1	11	58	1
Iron, total recoverable	91	11,000	5,600	1,400	14,000	72,000	450
Iron, dissolved	87	250	150	30	280	1,800	20
Lead, total recoverable	91	225	170	20	190	940	25
Lead, dissolved	87	20	12	2	19	86	1
Manganese, total recoverable	38	400	200	70	430	1,600	40
Manganese, dissolved	36	110	56	22	130	470	9
Mercury, total recoverable	88	0.3	0.2	0.0	0.3	1.6	<0.1
Mercury, dissolved	51	0.2	<0.1	0.0	0.3	2.3	0.0
Nickel, total recoverable	91	40	19	6	54	310	2
Nickel, dissolved	87	10	5	2	15	78	<1
Zinc, total recoverable	70	290	170	40	320	1,800	60
Zinc, dissolved	66	110	50	19	151	840	20
BIOLOGICAL							
Coliform, fecal, 0.7 µm-MF (colonies/100 mL)	37	6,000	2,500	1,800	11,000	62,000	400

Table 14. Statistical summary of discrete runoff sample data: Multiple-dwelling residential catchment—Continued

Property or constituent	Number of samples	Mean	Median	Standard error of mean	Standard deviation	Maximum	Minimum
OXYGEN DEMAND (mg/L)							
Oxygen demand, chemical, 0.25 N dichromate	58	160	89	31	240	1,400	31
Oxygen demand, biochemical, carbonaceous, 5-day at 20°C	45	15	7.2	3.0	20	110	3.1
Oxygen demand, biochemical, carbonaceous, 20-day	45	23	12	4.4	30	150	5.2
PHYSICAL PROPERTIES							
Turbidity (NTU)	72	49	28	7.2	62	320	2.0
Solids, residue at 180°C, dissolved (mg/L)	81	104	46	16	140	775	14
Solids, sum of constituents, dissolved (mg/L)	182	49	32	4	50	407	16
Sediment, suspended (mg/L)	86	638	333	87	804	4,300	8
ORGANICS							
Carbon, organic, dissolved (mg/L as C)	58	64	23	12	92	460	5
Carbon, organic, suspended (mg/L as C)	54	3.7	2.9	0.4	2.8	15	1.3
Cyanide, total (mg/L)	5	0.01	<0.01	0.00	0.00	<0.01	<0.01
Cyanide, dissolved (mg/L)	5	0.01	<0.01	0.00	0.00	<0.01	<0.01
Oil and grease, total recoverable, gravimetric (mg/L)	17	2	1	0	1	5	<1
Phenols, total recoverable (µg/L)	9	20	16	4	11	41	6
Pesticides (total recoverable, µg/L)							
Aldrin	27	0.01	<0.01	0.00	0.00	0.02	<0.01
Chlordane	26	0.25	0.10	0.05	0.27	1.2	<0.10
DDE	27	0.01	<0.01	0.00	0.01	0.06	<0.01
Diazinon	27	0.70	0.22	0.30	1.6	8.1	0.06
Dibromochloropropane	7	0.003	<0.003	0.00	0.00	0.004	<0.003
Dieldrin	27	0.01	<0.01	0.00	0.00	0.02	<0.01
Lindane	27	0.01	0.01	0.00	0.01	0.03	<0.01
Malathion	27	1.3	0.49	0.51	2.7	14	0.08
Methoxychlor	27	0.01	<0.01	0.00	0.00	0.02	<0.01
Parathion	27	0.20	0.06	0.09	0.48	2.5	<0.01
2,4-D	26	0.36	0.08	0.16	0.80	3.7	<0.01

Other organics analyzed but not detected

Organic (total recoverable)	Detection limit (µg/L)	Number of samples
Benzene	1	7
Chlorobenzene	1	7
DDD	0.01	27
DDT	0.01	*27
Endosulfan	0.01	27
Endrin	0.01	27
Ethion	0.01	27
Ethylbenzene	1	7
Gross polychlorinated biphenyls	0.1	**27
Gross polychlorinated naphthalenes	0.1	27
Heptachlor	0.01	27
Heptachlor epoxide	0.01	27
Methomyl	2	8
Methyl parathion	0.01	27
Methyl trithion	0.01	27
Mirex	0.01	27
Perthane	0.1	27
Propham	2	8
Sevin	2	8
Silvex	0.01	26
Toxaphene	1	27
Trithion	0.01	27
2,4-DP	0.01	26
2,4,5-T	0.01	26

*Three samples had concentrations equal to the detection limit.

**One sample had a concentration equal to the detection limit.

Table 15. Statistical summary of discrete runoff sample data: Commercial catchment

[Statistical calculations include analytical detection limit concentration for those analyses which are reported to be less than detection limit. Other organics were analyzed for but not detected and are given at the end of this table. <, actual value is less than value shown]

Property or constituent	Number of samples	Mean	Median	Standard error of mean	Standard deviation	Maximum	Minimum
INORGANICS							
Field measurements							
Specific conductance (µS/cm at 25°C)	256	90	28	9	146	868	8
pH (units)	203	6.9	6.9	0.0	0.4	8.9	6.1
Major ions (mg/L)							
Hardness, total (as $CaCO_3$)	95	49	11	8	73	330	3
Calcium, dissolved	96	14	3.4	2.1	20	100	0.8
Magnesium, dissolved	[illegible]	3.5	0.7	0.6	5.6	22	0.1
Sodium, dissolved	96	6.8	2.7	0.9	9.0	37	0.6
Potassium, dissolved	96	2.9	1.1	0.4	3.7	15	0.3
Alkalinity, total (as $CaCO_3$)	96	36	10	5	52	257	1
Sulfate, dissolved	95	21	7	3.3	32	190	3.1
Chloride, dissolved	95	5.4	1.8	0.8	7.4	31	0.2
Silica, dissolved	64	3.2	1.5	0.8	6.4	44	0.5
Nutrients (mg/L)							
Nitrogen, nitrate, dissolved (as N)	39	0.78	0.41	0.15	0.93	4.5	0.14
Nitrogen, nitrite plus nitrate, dissolved (as N)	87	2.1	0.55	0.44	4.1	22	<0.10
Nitrogen, ammonia, dissolved (as N)	87	2.2	1.0	0.33	3.1	17	0.22
Nitrogen, ammonia plus organic, total (as N)	82	6.3	2.3	1.0	9.2	61	0.57
Nitrogen, ammonia plus organic, dissolved (as N)	87	5.7	2.1	0.91	8.5	44	<0.10
Nitrogen, organic, dissolved (as N)	85	3.6	1.2	0.61	5.6	27	0.00
Nitrogen, dissolved (as N)	83	8.1	2.8	1.4	13	66	0.70
Phosphorus, total (as P)	87	0.63	0.25	0.14	1.3	9.1	0.03
Phosphorus, dissolved (as P)	87	0.45	0.14	0.12	1.2	8.0	0.02
Phosphorus, orthophosphate, total (as P)	87	0.33	0.12	0.07	0.66	5.0	0.03
Phosphorus, orthophosphate, dissolved (as P)	87	0.28	0.09	0.07	0.65	4.8	<0.02
Metals (µg/L)							
Aluminum, total recoverable	19	7,800	3,400	2,600	11,000	45,000	120
Aluminum, dissolved	18	200	75	80	350	1,500	20
Arsenic, total	95	4	2	0	3	17	<1
Arsenic, dissolved	49	3	1	1	4	18	<1
Cadmium, total recoverable	49	2	1	0	2	12	<1
Cadmium, dissolved	49	1	<1	0	1	5	<1
Chromium, total recoverable	68	12	11	1	7	37	1
Chromium, dissolved	49	2	<1	0	2	13	<1
Copper, total recoverable	68	35	18	7	61	380	6
Copper, dissolved	68	7	4	1	8	45	1
Iron, total recoverable	95	4,700	1,600	890	8,700	57,000	140
Iron, dissolved	95	220	89	31	300	1,400	<10
Lead, total recoverable	95	210	100	27	260	1,200	9
Lead, dissolved	95	26	12	4	39	250	<1
Manganese, total recoverable	46	420	280	50	360	1,700	30
Manganese, dissolved	46	200	105	34	230	910	8
Mercury, total recoverable	95	0.2	0.1	0.0	0.1	0.5	<0.1
Mercury, dissolved	49	0.1	<0.1	0.0	0.1	0.7	<0.0
Nickel, total recoverable	94	18	10	2	22	120	1
Nickel, dissolved	95	10	4	1	12	53	<1
Zinc, total recoverable	68	380	150	70	590	3,400	60
Zinc, dissolved	68	200	80	42	350	2,400	10
BIOLOGICAL							
Coliform, fecal, 0.7 µm-MF (colonies/100 mL)	38	11,000	2,500	8,400	52,000	32,000	140

Table 15. Statistical summary of discrete runoff sample data: Commercial catchment—Continued

Property or constituent	Number of samples	Mean	Median	Standard error of mean	Standard deviation	Maximum	Minimum
OXYGEN DEMAND (mg/L)							
Oxygen demand, chemical, 0.25 N dichromate	50	95	63	13	92	460	12
Oxygen demand, biochemical, carbonaceous, 5-day at 20°C	44	8.4	5.6	1.2	7.0	30	2.7
Oxygen demand, biochemical, carbonaceous, 20-day	44	13	7.7	2.0	13	64	3.4
PHYSICAL PROPERTIES							
Turbidity (NTU)	71	31	9.8	6.1	52	300	1.6
Solids, residue at 180°C, dissolved (mg/L)	87	143	39	24	244	1,010	1
Solids, sum of constituents, dissolved (mg/L)	88	78	29	10	91	413	9
Sediment, suspended	94	264	57	59	571	3,720	2
ORGANICS							
Carbon, organic, dissolved (mg/L as C)	47	54	24	9	64	260	4
Carbon, organic, suspended (mg/L as C)	46	2.5	1.9	0.2	1.7	10	0.9
Cyanide, total (mg/L)	6	0.01	<0.01	0.00	0.00	<0.01	<0.01
Cyanide, dissolved (mg/L)	6	0.01	<0.01	0.00	0.00	<0.01	<0.01
Oil and grease, total recoverable, gravimetric (mg/L)	18	4	3	1	6	26	0
Phenols, total recoverable (μg/L)	9	22	17	5	15	52	6
Pesticides (total recoverable, μg/L)							
Chlordane	23	0.12	0.10	0.01	0.05	0.30	<0.10
Diazinon	24	1.6	0.39	0.76	3.7	18	0.13
Dibromochloropropane	8	0.004	<0.003	0.001	0.002	0.01	<0.003
Endosulfan	24	0.01	<0.01	0.00	0.01	0.07	<0.01
Lindane	24	0.01	0.01	0.00	0.01	0.03	0.01
Malathion	24	0.28	0.23	0.05	0.25	1.4	0.08
Methyl parathion	24	0.01	<0.01	0.00	0.00	0.03	<0.01
Parathion	24	0.16	0.09	0.04	0.20	0.90	<0.01
2,4-D	23	0.07	0.01	0.03	0.14	0.63	<0.01

Other organics analyzed but not detected

Organic (total recoverable)	Detection limit (μg/L)	Number of samples	Organic (total recoverable)	Detection limit (μg/L)	Number of samples
Aldrin	0.01	24	Heptachlor	0.01	24
Benzene	1	7	Heptachlor epoxide	0.01	24
Chlorobenzene	1	7	Methomyl	2	7
DDD	0.01	24	Methoxychlor	0.01	24
DDE	0.01	*24	Methyl trithion	0.01	24
DDT	0.01	24	Mirex	0.01	24
Dieldrin	0.01	**24	Perthane	0.1	24
Endrin	0.01	24	Propham	2	7
Ethion	0.01	24	Sevin	2	7
Ethylbenzene	1	7	Silvex	0.01	23
Gross polychlorinated biphenyls	0.1	***24	Toxaphene	1	24
			Trithion	0.01	24
Gross polychlorinated naphthalenes	0.1	24	2,4-DP	0.01	23
			2,4,5-T	0.01	23

*Twelve samples concentrations equal to the detection limit.
**One sample had a concentration equal to the detection limit.
***Two samples had concentrations equal to the detection limit.

Table 16. Results of statistical comparison testing between catchments using discrete runoff quality data

Constituents for which no statistical difference (α=0.05) was determined for the listed catchments:

Industrial, single, multiple, commercial

Nitrogen, nitrate, dissolved
Cadmium, total recoverable and dissolved
Chromium, total recoverable and dissolved
Nickel, dissolved
Chlordane, total recoverable
Diazinon, total recoverable
Parathion, total recoverable
Malathion, total recoverable
2,4-D, total recoverable
Oil and grease, total recoverable
Coliform, fecal

Industrial, commercial

Mercury, total recoverable

Industrial, single

Lindane, total recoverable

Industrial, multiple, commercial

Lead, dissolved

Single, multiple, commercial

Nitrogen, dissolved
Nitrogen, nitrite plus nitrate, dissolved
Nitrogen, organic, dissolved
Nitrogen, ammonia, dissolved
Nitrogen, ammonia plus organic, total and dissolved
Magnesium, dissolved
Chloride, dissolved
Sulfate, dissolved
Arsenic, total and dissolved
Copper, dissolved
Mercury, dissolved
Zinc, total recoverable
Oxygen demand, chemical

Industrial, multiple

Sediment, suspended
Iron, total recoverable

Multiple, commercial

Carbon, organic, dissolved
Oxygen demand, biochemical, 5-day
Oxygen demand, biochemical, 20-day

Single, multiple

Phosphorus, total and dissolved
Phosphorus, orthophosphate, total and dissolved
Specific conductance
Calcium, dissolved
Potassium, dissolved
Hardness, total
Solids, sum of constituents, dissolved
Solids, residue at 180°C, dissolved
Turbidity
Alkalinity, total
Copper, total recoverable
Iron, dissolved
Lead total recoverable
Mercury, total recoverable
Zinc, dissolved
Carbon, organic, suspended

Industrial, single, multiple

Silica, dissolved
Nickel, total recoverable

Significantly different for all four catchments: ph and sodium, dissolved

Table 17. Results of linear regression analysis using discrete runoff sample data

[Form of equation: $y = a + bx$]

Calculated constituent concentration, in milligrams per liter (dependent variable, y)	Regression constant (a)	Regression coefficient (b)	Constituent concentration, in micrograms per liter or microsiemens per centimeter at 25°C (independent variable, x)	Adjusted percentage of variation explained (R^2)	Root mean square error	Number of data observations
			Single-dwelling residential catchment			
Phosphorus, dissolved	-0.00419	0.006020	Specific conductance	87	0.110	57
Phosphorus, dissolved	0.0134	0.750	Phosphorus, total	95	0.0722	51
Phosphorus, dissolved	0.0137	1.17	Phosphorus, orthophosphate, dissolved	95	0.0678	55
Nitrogen, ammonia, dissolved	0.00290	0.419	Nitrogen, ammonia plus organic, dissolved	96	0.307	48
Nitrogen, ammonia plus organic, dissolved	0.339	0.648	Nitrogen, ammonia plus organic, total	68	0.859	40
Nitrogen, ammonia plus organic, dissolved	-0.772	0.0574	Specific conductance (first rain season)	92	0.455	28
Nitrogen, ammonia plus organic, dissolved	-0.0847	0.0754	Specific conductance (second rain season)	97	0.841	19
Nitrogen, nitrite plus nitrate, dissolved	0.0772	*	0.000226(specific conductance)^2 - 0.000000584(specific conductance)^3	96	0.227	57
Solids, sum of constituents, dissolved	6.84	0.576	Specific conductance	97	3.21	41
Oxygen demand, chemical	36.1	1.48	Specific conductance	74	22.9	27
Alkalinity, total	6.26	0.192	Specific conductance	78	4.85	57
			Multiple-dwelling residential catchment			
Phosphorus, dissolved	0.0372	0.00532	Specific conductance	86	0.122	68
Phosphorus, dissolved	0.00970	0.756	Phosphorus, total	36	0.0713	50
Phosphorus, orthophosphate, dissolved	0.0171	0.680	Phosphorus, dissolved	88	0.0879	60
Nitrogen, ammonia, dissolved	0.0190	0.389	Nitrogen, ammonia plus organic, dissolved	94	0.358	60
Nitrogen, ammonia plus organic, dissolved	-0.0499	0.890	Nitrogen, ammonia plus organic, total	90	0.482	49
Nitrogen, ammonia plus organic, dissolved	-0.705	0.0604	Specific conductance	95	0.837	59
Nitrogen, nitrite plus nitrate, dissolved	-0.382	0.0190	Specific conductance	95	0.257	68
Solids, sum of constituents, dissolved	4.60	0.647	Specific conductance	99	5.20	53
Alkalinity, total	3.54	0.239	Specific conductance	89	5.18	70
			**Commercial catchment			
Phosphorus, dissolved	0.00920	0.00377	Specific conductance	93	0.0278	34
Phosphorus, dissolved	-0.0154	0.916	Phosphorus, total	93	0.0268	35
Phosphorus, dissolved	0.0229	1.31	Phosphorus, orthophosphate, dissolved	93	0.0516	60
Nitrogen, ammonia, dissolved	0.0331	0.547	Nitrogen, ammonia plus organic, dissolved	94	0.180	35
Nitrogen, ammonia plus organic, dissolved	0.104	0.0481	Specific conductance	90	0.433	34
Nitrogen, ammonia plus organic, dissolved	0.0432	0.860	Nitrogen, ammonia plus organic, total	96	0.260	35
Nitrogen, nitrite plus nitrate, dissolved	-0.0434	0.0167	Specific conductance	94	0.115	34
Solids, sum of constituents, dissolved	9.89	0.465	Specific conductance	93	3.11	36
Alkalinity, total	2.59	0.244	Specific conductance	80	6.89	62

*Nonlinear relation; form of equation: $y = a + cx^2 + dx^3$.

**Only first rain season data used because of construction activity during second season.

Table 18. Constituent storm-runoff loads: Industrial catchment

[Time is beginning and end of runoff, in hours. Total runoff volume is depth in inches covering the catchment drainage area. EMC is event mean concentration of constituent, in milligrams per liter (mg/L) or micrograms per liter (µg/L), as noted. Event load is in pounds. n is number of samples used in computation of storm-runoff load. Composite samples are identified by a C. <, actual value is less than value shown]

Date	Time	Total runoff volume	EMC	Event load	n
Nitrogen, ammonia plus organic, dissolved (mg/L as N)					
1981					
Nov. 12-13	2036-1232	0.054	19	64	9
Nov. 17	0448-0856	.018	22	25	4
Dec. 29	1610-2230	.024	19	29	C
1982					
Jan. 4-5	0850-0320	.211	12	165	10
Feb. 14-15	1820-0930	.052	20	66	C
Feb. 15-16	2034-1006	.075	16	76	C
Mar. 9-10	1948-0946	.035	17	38	10
Mar. 25-26	2220-0422	.033	14	30	7
Mar. 29	1254-1738	.035	8.1	18	C
Sept. 24	0410-0800	.004	28	7.6	11
Oct. 25	0246-0556	.002	21	2.2	10
Nov. 9	1210-1828	.045	15	43	C
Dec. 22	0330-1436	.199	6.5	81	C
1983					
Jan. 18-19	1906-0328	.257	6.0	98	8
Jan. 24	0102-1228	.143	3.6	32	C
Nitrogen, nitrite plus nitrate, dissolved (mg/L as N)					
1981					
Nov. 12-13	2036-1232	0.054	2.3	7.6	13
Nov. 17	0448-0856	.018	0.47	0.53	4
Dec. 29	1610-2230	.024	1.1	1.7	C
1982					
Jan. 4-5	0850-0320	.211	1.0	13	10
Feb. 14-15	1820-0930	.052	0.28	0.91	C
Feb. 15-16	2034-1006	.075	0.41	2.0	C
Mar. 9-10	1948-0946	.035	0.52	1.2	12
Mar. 25-26	2220-0422	.033	1.1	2.4	7
Mar. 29	1254-1738	.035	0.48	1.1	C
Sept. 24	0410-0800	.004	3.9	1.1	12
Oct. 25	0246-0556	.002	2.3	0.24	10
Nov. 9	1210-1828	.045	0.40	1.1	C
Dec. 22	0330-1436	.199	0.77	9.6	C
1983					
Jan. 18-19	1906-0328	.257	0.60	9.7	8
Jan. 24	0102-1228	.143	0.43	3.9	C
Phosphorus, dissolved (mg/L as P)					
1981					
Nov. 12-13	2036-1232	0.054	5.4	18	13
Nov. 17	0448-0856	.018	6.6	7.5	4
Dec. 29	1610-2230	.024	7.2	11	C
1982					
Jan. 4-5	0850-0320	.211	4.2	56	10
Feb. 14-15	1820-0930	.052	7.8	26	C
Phosphorus, dissolved (mg/L as P)--Continued					
1982					
Feb. 15-16	2034-1006	0.075	6.7	32	C
Mar. 9-10	1948-0946	.035	6.8	15	12
Mar. 25-26	2220-0422	.033	5.1	11	7
Mar. 29	1254-1738	.035	3.0	6.6	C
Sept. 24	0410-0800	.004	4.8	1.3	11
Oct. 25	0246-0556	.002	4.7	0.49	10
Nov. 9	1210-1828	.045	3.5	9.9	C
Dec. 22	0330-1436	.199	2.7	34	C
1983					
Jan. 18-19	1906-0328	.257	2.4	40	8
Jan. 24	0102-1228	.143	2.0	18	C
Aluminum, total recoverable (µg/L)					
1982					
Nov. 9	1210-1828	0.045	7,100	20	C
Dec. 22	0330-1436	.199	6,000	75	C
1983					
Jan. 24	0102-1228	.143	6,300	57	C
Arsenic, total (µg/L)					
1981					
Nov. 12-13	2036-1232	0.054	19	0.06	13
Nov. 17	0448-0856	.018	30	0.03	4
Dec. 29	1610-2230	.024	19	0.03	C
1982					
Jan. 4-5	0850-0320	.211	27	0.36	10
Feb. 14-15	1820-0930	.052	18	0.06	C
Feb. 15-16	2034-1006	.075	25	0.12	C
Mar. 9-10	1948-0946	.035	14	0.03	12
Mar. 11	0002-0706	.048	28	0.08	4
Mar. 25-26	2220-0422	.033	8	0.02	7
Mar. 28	1302-2202	.132	25	0.21	8
Mar. 29	1254-1738	.035	23	0.05	C
Sept. 24	0410-0800	.004	11	<0.01	12
Oct. 25	0246-0556	.002	11	<0.01	10
Nov. 9	1210-1828	.045	11	0.03	C
Dec. 22	0330-1436	.199	12	0.15	C
1983					
Jan. 18-19	1906-0328	.257	10	0.16	8
Jan. 24	0102-1228	.143	9	0.08	C
Chromium, total recoverable (µg/L)					
1981					
Nov. 12-13	2036-1232	0.054	29	0.10	13
Nov. 17	0448-0856	.018	24	0.03	4
Dec. 29	1610-2230	.024	35	0.05	C

Table 18. Constituent storm-runoff loads: Industrial catchment--Continued

Date	Time	Total runoff volume	EMC	Event load	n
Chromium, total recoverable (µg/L)--Continued					
1982					
Jan. 4-5	0850-0320	0.211	30	0.40	10
Feb. 14-15	1820-0930	.052	12	0.04	C
Feb. 15-16	2034-1006	.075	12	0.06	C
Mar. 9-10	1948-0946	.035	8	0.02	12
Mar. 11	0002-0706	.048	13	0.04	4
Mar. 25-26	2220-0422	.033	8	0.02	7
Mar. 28	1302-2202	.132	36	0.30	8
Mar. 29	1254-1738	.035	51	0.11	C
Nov. 9	1210-1828	.045	12	0.03	C
Dec. 22	0330-1436	.199	10	0.12	C
1983					
Jan. 24	0102-1228	.143	13	0.12	C
Copper, total recoverable (µg/L)					
1981					
Nov. 12-13	2036-1232	0.054	100	0.35	13
Nov. 17	0448-0856	.018	64	0.07	4
Dec. 29	1610-2230	.024	100	0.15	C
1982					
Jan. 4-5	0850-0320	.211	70	0.93	10
Feb. 14-15	1820-0930	.052	60	0.20	C
Feb. 15-16	2034-1006	.075	58	0.28	C
Mar. 9-10	1948-0946	.035	58	0.13	12
Mar. 11	0002-0706	.048	58	0.18	4
Mar. 25-26	2220-0422	.033	39	0.08	7
Mar. 28	1302-2202	.132	110	0.95	8
Mar. 29	1254-1738	.035	72	0.16	C
Nov. 9	1210-1828	.045	65	0.18	C
Dec. 22	0330-1436	.199	44	0.55	C
1983					
Jan. 24	0102-1228	.143	39	0.35	C
Iron, total recoverable (µg/L)					
1981					
Nov. 12-13	2036-1232	0.054	10,000	35	13
Nov. 17	0448-0856	.018	11,000	13	4
Dec. 29	1610-2230	.024	9,600	14	C
1982					
Jan. 4-5	0850-0320	.211	12,000	158	10
Feb. 14-15	1820-0930	.052	6,500	21	C
Feb. 15-16	2034-1006	.075	8,200	39	C
Mar. 9-10	1948-0946	.035	4,300	9.5	12
Mar. 11	0002-0706	.048	7,600	23	4
Mar. 25-26	2220-0422	.033	4,000	8.3	7
Mar. 28	1302-2202	.132	34,000	279	8
Mar. 29	1254-1738	.035	18,000	40	C
Sept. 24	0410-0800	.004	13,800	3.7	12
Oct. 25	0246-0556	.002	11,000	1.2	10
Nov. 9	1210-1828	.045	9,000	26	C
Dec. 22	0330-1436	.199	6,800	85	C
Iron, total recoverable (µg/L)--Continued					
1983					
Jan. 18-19	1906-0328	0.257	11,000	183	8
Jan. 24	0102-1228	.143	8,000	72	C
Lead, total recoverable (µg/L)					
1981					
Nov. 12-13	2036-1232	0.054	73	0.25	13
Nov. 17	0448-0856	.018	49	0.06	4
Dec. 29	1610-2230	.024	98	0.15	C
1982					
Jan. 4-5	0850-0320	.211	88	1.2	10
Feb. 14-15	1820-0930	.052	34	0.11	C
Feb. 15-16	2034-1006	.075	27	0.13	C
Mar. 9-10	1948-0946	.035	48	0.11	12
Mar. 11	0002-0706	.048	70	0.21	4
Mar. 25-26	2220-0422	.033	50	0.10	7
Mar. 28	1302-2202	.132	210	1.8	8
Mar. 29	1254-1738	.035	200	0.44	C
Sept. 24	0410-0800	.004	82	0.02	12
Oct. 25	0246-0556	.002	140	0.01	10
Nov. 9	1210-1828	.045	86	0.24	C
Dec. 22	0330-1436	.199	70	0.88	C
1983					
Jan. 18-19	1906-0328	.257	81	1.3	8
Jan. 24	0102-1228	.143	72	0.65	C
Manganese, total recoverable (µg/L)					
1982					
Sept. 24	0410-0800	0.004	570	0.15	12
Oct. 25	0246-0556	.002	430	0.04	10
Nov. 9	1210-1828	.045	280	0.80	C
Dec. 22	0330-1436	.199	230	2.9	C
1983					
Jan. 18-19	1906-0328	.257	360	5.8	8
Jan. 24	0102-1228	.143	250	2.2	C
Mercury, total recoverable (µg/L)					
1981					
Nov. 12-13	2036-1232	0.054	0.1	<0.01	13
Nov. 17	0448-0856	.018	0.1	<0.01	4
Dec. 29	1610-2230	.024	0.2	<0.01	C
1982					
Jan. 4-5	0850-0320	.211	0.2	<0.01	10
Feb. 14-15	1820-0930	.052	0.8	<0.01	C
Feb. 15-16	2034-1006	.075	1.4	0.01	C
Mar. 9-10	1948-0946	.035	0.1	<0.01	12
Mar. 11	0002-0706	.048	0.1	<0.01	4
Mar. 25-26	2220-0422	.033	0.1	<0.01	7
Mar. 28	1302-2202	.132	0.1	<0.01	8
Mar. 29	1254-1738	.035	0.1	<0.01	C
Sept. 24	0410-0800	.004	0.2	<0.01	12

Table 18. Constituent storm-runoff loads: industrial catchment—Continued

Date	Time	Total runoff volume	EMC	Event load	n
Mercury, total recoverable (μg/L)--Continued					
1982					
Oct. 25	0246-0556	0.002	1.1	<0.01	10
Nov. 9	1210-1828	.045	0.2	<0.01	C
Dec. 22	0330-1436	.199	1.4	0.02	C
1983					
Jan. 18-19	1906-0328	.257	0.1	<0.001	8
Nickel, total recoverable (μg/L)					
1981					
Nov. 12-13	2036-1232	0.054	34	0.12	13
Nov. 17	0448-0856	.018	16	0.02	4
Dec. 29	1610-2230	.024	26	0.04	C
1982					
Jan. 4-5	0850-0320	.211	24	0.32	10
Feb. 14-15	1820-0930	.052	16	0.05	C
Feb. 15-16	2034-1006	.075	17	0.08	C
Mar. 9-10	1948-0946	.035	5.8	0.01	12
Mar. 11	0002-0706	.048	30	0.09	4
Mar. 25-26	2220-0422	.033	24	0.05	7
Mar. 28	1302-2202	.132	52	0.43	8
Mar. 29	1254-1738	.035	35	0.08	C
Sept. 24	0410-0800	.004	39	0.01	12
Oct. 25	0246-0556	.002	28	<0.01	10
Nov. 9	1210-1828	.045	17	0.05	C
Dec. 22	0330-1436	.199	24	0.30	C
1983					
Jan. 18-19	1906-0328	.257	25	0.41	8
Jan. 24	0102-1228	.143	14	0.12	C
Zinc, total recoverable (μg/L)					
1981					
Nov. 12-13	2036-1232	0.054	770	2.6	13
Nov. 17	0448-0856	.018	620	0.70	4
Dec. 29	1610-2230	.024	580	0.88	C
1982					
Jan. 4-5	0850-0320	.211	460	6.1	10
Feb. 14-15	1820-0930	.052	420	1.4	C
Feb. 15-16	2034-1006	.075	390	1.8	C
Mar. 9-10	1948-0946	.035	420	0.94	12
Mar. 11	0002-0706	.048	460	1.4	4
Mar. 25-26	2220-0422	.033	470	0.98	7
Mar. 28	1302-2202	.132	840	7.0	8
Mar. 29	1254-1738	.035	520	1.1	C
Nov. 9	1210-1828	.045	560	1.6	C
Dec. 22	0330-1436	.199	370	4.6	C
1983					
Jan. 24	0102-1228	.143	320	2.9	C
Oxygen demand, chemical, 0.25 N dichromate (mg/L)					
1981					
Nov. 12-13	2036-1232	0.054	970	3,260	13
Nov. 17	0448-0856	.018	930	1,050	4
Dec. 29	1610-2230	.024	630	952	C
1982					
Jan. 4-5	0850-0320	.211	500	6,710	10
Feb. 14-15	1820-0930	.052	630	2,060	C
Feb. 15-16	2034-1006	.075	470	2,220	C
Mar. 9-10	1948-0946	.035	420	929	12
Mar. 25-26	2220-0422	.033	340	708	7
Nov. 9	1210-1828	.045	590	1,670	C
Dec. 22	0330-1436	.199	290	3,640	C
1983					
Jan. 24	0102-1228	.143	300	2,702	C
Solids, sum of constituents, dissolved (mg/L)					
1981					
Nov. 12-13	2036-1232	0.054	201	678	12
Nov. 17	0448-0856	.018	200	225	4
Dec. 29	1610-2230	.024	148	224	C
1982					
Jan. 4-5	0850-0320	.211	116	1,540	10
Feb. 14-15	1820-0930	.052	22	364	C
Feb. 15-16	2034-1006	.075	145	685	C
Mar. 9-10	1948-0946	.035	153	340	10
Mar. 25-26	2220-0422	.033	170	354	7
Mar. 28	1302-2202	.132	86	713	8
Mar. 29	1254-1738	.035	92	203	C
Sept. 24	0410-0800	.004	559	151	12
Oct. 25	0246-0556	.002	1,006	105	10
Nov. 9	1210-1828	.045	150	425	C
Dec. 22	0330-1436	.199	63	790	C
1983					
Jan. 18-19	1906-0328	.257	102	1,650	8
Jan. 24	0102-1228	.143	123	1,110	C
Sediment, suspended (mg/L)					
1982					
Feb. 14-15	1820-0930	0.052	231	756	C
Feb. 15-16	2034-1006	.075	366	1,730	C
Mar. 29	1254-1738	.035	848	1,870	C
Sept. 24	0410-0800	.004	635	172	12
Oct. 25	0246-0556	.002	637	66	10
Nov. 9	1210-1828	.045	636	1,800	C
Dec. 22	0330-1436	.199	490	6,140	C
1983					
Jan. 18-19	1906-0328	.257	954	15,400	7
Jan. 24	0102-1228	.143	409	3,700	C

Table 18. Constituent storm-runoff loads: Industrial catchment—Continued

Date	Time	Total runoff volume	EMC	Event load	n
Carbon, organic, dissolved (mg/L)					
1981					
Nov. 12-13	2036-1232	0.054	220	751	13
Nov. 17	0448-0856	.018	87	98	4
Dec. 29	1610-2230	.024	85	128	C
1982					
Jan. 4-5	0850-0320	.211	72	962	10
Feb. 14-15	1820-0930	.052	230	753	C
Feb. 15-16	2034-1006	.075	86	406	C
Mar. 9-10	1948-0946	.035	220	480	12
Mar. 25-26	2220-0422	.033	200	409	7
Mar. 29	1254-1738	.035	750	1,700	C
Nov. 9	1210-1828	.045	60	170	C
Dec. 22	0330-1436	.199	20	251	C
1983					
Jan. 24	0102-1228	.143	24	216	C
Carbon, organic, suspended (mg/L)					
1981					
Nov. 12-13	2036-1232	0.054	28	96	13
Nov. 17	0448-0856	.018	40	45	3
Dec. 29	1610-2230	.024	28	42	C
1982					
Jan. 4-5	0850-0320	.211	35	468	10
Feb. 14-15	1820-0930	.052	22	72	C
Feb. 15-16	2034-1006	.075	22	104	C
Mar. 9-10	1948-0946	.035	21	47	12
Mar. 25-26	2220-0422	.033	10	20	7
Mar. 29	1254-1738	.035	36	80	C
Nov. 9	1210-1828	.045	38	108	C
Dec. 22	0330-1436	.199	22	276	C

Table 19. Constituent storm-runoff loads: Single-dwelling residential catchment

[Time is beginning and end of runoff, in hours. Total runoff volume is depth in inches covering the catchment drainage area. EMC is event mean concentration of constituent, in milligrams per liter (mg/L) or micrograms per liter (μg/L), as noted. Event load is in pounds. n is number of samples used in computation of storm-runoff load. Sample concentrations were determined by laboratory analyses except where noted by an e, which indicates sample concentration were estimated using a regression equation. Composite samples are identified by a C. <, actual value is less than value shown]

Date	Time	Total runoff volume	EMC	Event load	n
Nitrogen, ammonia plus organic, dissolved (mg/L as N)					
1981					
Nov. 12-13	2012-0040	0.041	4.4	3.8	6
Nov. 17	0440-0756	.044	1.6	1.5	3
1982					
Mar. 25-26	2236-0240	.031	2.2	1.5	6
Mar. 31	1648-2320	.234	0.68	3.4	9
Sept. 24	0342-0550	.028	12	6.9	6
Oct. 25	0258-0432	.010	6.2	1.3	6
Oct. 26	0214-0512	.173	2.2	8.2	7
Dec. 21	1818-2340	.047	2.6	2.6	e5
Dec. 22	1500-1732	.124	0.80	2.1	C
1983					
Jan. 18-19	1846-0106	.171	1.7	6.3	9
Jan. 21-22	2236-0110	.014	3.6	1.1	e3
Jan. 22	0510-1354	.173	2.0	7.5	e29
Jan. 24	0018-1136	.235	1.7	8.5	C
Jan. 29	2206-0418	.097	2.3	4.8	e9
Feb. 6-7	0720-0000	.138	2.3	6.6	e11
Nitrogen, ammonia plus organic, dissolved (mg/L as N)--Continued					
1983					
Feb. 7-8	2152-0104	0.113	1.2	2.9	e11
Feb. 25	1434-1802	.023	4.8	2.3	e4
Feb. 28 - Mar. 1	1800-0438	.301	0.70	4.5	C
Mar. 16	1702-2040	.077	1.4	2.3	C
Mar. 23	2000-2346	.134	1.5	4.3	C
Nitrogen, nitrite plus nitrate, dissolved (mg/L as N)					
1981					
Nov. 12-13	2012-0040	0.041	1.5	1.3	6
Nov. 17	0440-0756	.044	0.41	0.39	3
1982					
Mar. 25-26	2236-0240	.031	0.63	0.42	6
Mar. 31	1648-2320	.234	0.17	0.87	9
Sept. 24	0342-0550	.028	3.2	1.9	7
Oct. 25	0258-0432	.010	1.2	0.26	6
Oct. 26	0214-0512	.173	0.33	1.2	7

Table 19. Constituent storm-runoff loads: Single-dwelling residential catchment—Continued

Date	Time	Total runoff volume	EMC	Event load	n
Nitrogen, nitrite plus nitrate, dissolved (mg/L as N)--Continued					
1982					
Dec. 21	1818-2340	0.047	0.34	0.34	e5
Dec. 22	1500-1732	.124	0.68	1.8	C
1983					
Jan. 18-19	1846-0106	.171	0.24	0.86	9
Jan. 21-22	2236-0110	.014	0.60	0.18	e3
Jan. 22	0510-1354	.173	0.26	0.96	e29
Jan. 24	0018-1136	.235	0.39	2.0	C
Jan. 28-29	2206-0418	.097	0.46	0.95	e9
Feb. 6-7	0720-0000	.138	0.30	0.89	e11
Feb. 7-8	2152-0104	.113	0.15	0.36	e11
Feb. 25	1434-1802	.023	0.97	0.47	e4
Feb. 28 - Mar. 1	1800-0438	.301	0.14	0.90	C
Mar. 16	1702-2040	.077	0.50	0.82	C
Mar. 23	2000-2346	.134	0.15	0.43	C
Phosphorus, dissolved (mg/L as P)					
1981					
Nov. 12-13	2012-0040	0.041	0.58	0.51	6
Nov. 17	0440-0756	.044	0.31	0.30	3
1982					
Mar. 25-26	2236-0240	.031	0.27	0.18	6
Mar. 31	1648-2320	.234	0.11	0.53	9
Sept. 24	0342-0550	.028	0.99	0.59	7
Oct. 25	0258-0432	.010	0.37	0.08	6
Oct. 26	0214-0512	.173	0.20	0.72	7
Dec. 21	1818-2340	.047	0.21	0.21	e5
Dec. 22	1500-1732	.124	0.20	0.53	C
Jan. 18-19	1846-0106	.171	0.20	0.72	9
Jan. 21-22	2236-0110	.014	0.29	0.08	e3
Jan. 22	0510-1354	.173	0.16	0.61	e29
Jan. 24	0018-1136	.235	0.14	0.70	C
Jan. 28-29	2206-0418	.097	0.19	0.39	e9
Feb. 6-7	0720-0000	.138	0.18	0.54	e11
Feb. 7-8	2152-0104	.113	0.10	0.24	e11
Feb. 25	1434-1802	.023	0.38	0.19	e4
Feb. 28 - Mar. 1	1800-0438	.301	0.09	0.58	C
Mar. 16	1702-2040	.077	0.15	0.25	C
Mar. 21	2000-2346	.134	0.15	0.43	C
Aluminum, total recoverable (µg/L)					
1982					
Dec. 22	1500-1732	0.124	2,300	6.1	C
1983					
Jan. 24	0018-1136	.235	1,500	7.5	C
Feb. 28 - Mar. 1	1800-0438	.301	3,400	22	C
Mar. 16	1702-2040	.077	560	0.92	C
Mar. 23	2000-2346	.134	600	1.7	C
Arsenic, total (µg/L)					
1981					
Nov. 12-13	2012-0040	0.041	4	<0.01	6
Nov. 17	0440-0756	.044	1	<0.01	3
1982					
Mar. 25-26	2236-0240	.031	1	<0.01	6
Sept. 24	0342-0550	.028	2	<0.01	7
Oct. 25	0258-0432	.010	3	<0.01	5
Oct. 26	0214-0512	.173	2	0.01	7
Dec. 22	1500-1732	.124	1	<0.01	C
1983					
Jan. 24	0018-1136	.235	1	<0.01	C
Feb. 28 - Mar. 1	1800-0438	.301	1	<0.01	C
Mar. 16	1702-2040	.077	1	<0.01	C
Mar. 23	2000-2346	.134	1	<0.01	C
Chromium, total recoverable (µg/L)					
1981					
Nov. 12-13	2012-0040	0.041	12	0.01	6
Nov. 17	0440-0756	.044	13	0.01	3
1982					
Mar. 25-26	2236-0240	.031	5	<0.01	6
Mar. 31	1648-2320	.234	6	0.03	9
Dec. 22	1500-1732	.124	1	<0.01	C
1983					
Jan. 24	0018-1136	.235	4	0.02	C
Feb. 28 - Mar. 1	1800-0438	.301	13	0.08	C
Mar. 16	1702-2040	.077	4	0.01	C
Copper, total recoverable (µg/L)					
1981					
Nov. 12-13	2012-0040	0.041	39	0.03	6
Nov. 17	0440-0756	.044	24	0.02	3
1982					
Mar. 25-26	2236-0240	.031	14	0.01	6
Mar. 31	1648-2320	.234	11	0.05	9
1983					
Jan. 24	0018-1136	.235	10	0.05	C
Feb. 28 - Mar. 1	1800-0438	.301	10	0.06	C
Mar. 16	1702-2040	.077	7	0.01	C
Mar. 23	2000-2346	.134	7	0.02	C
Iron, total recoverable (µg/L)					
1981					
Nov. 12-13	2012-0040	0.041	2,400	2.1	6
Nov. 17	0440-0756	.044	2,400	2.2	3
1982					
Mar. 25-26	2236-0240	.031	450	0.30	6
Mar. 31	1648-2320	.234	900	4.5	9

Table 19. Constituent storm-runoff loads: Single-dwelling residential catchment—Continued

Date	Time	Total runoff volume	EMC	Event load	n
Iron, total recoverable (µg/L)--Continued					
1982					
Sept. 24	0342-0550	0.028	10,000	6.0	7
Oct. 25	0258-0432	.010	7,600	1.6	6
Oct. 26	0214-0512	.173	5,000	18	7
1983					
Jan. 18-19	1846-0106	.171	1,200	4.4	9
Jan. 24	0018-1136	.235	2,200	11	C
Feb. 28 - Mar. 1	1800-0438	.301	4,600	30	C
Mar. 16	1702-2040	.077	790	1.3	C
Mar. 23	2000-2346	.134	950	2.7	C
Lead, total recoverable (µg/L)					
1981					
Nov. 12-13	2012-0040	0.041	270	0.24	6
Nov. 17	0440-0756	.044	290	0.27	3
1982					
Mar. 25-26	2236-0240	.031	80	0.05	6
Mar. 31	1648-2320	.234	87	0.43	9
Sept. 24	0342-0550	.028	740	0.44	7
Oct. 25	0258-0432	.010	570	0.12	5
Oct. 26	0214-0512	.173	360	1.3	7
1983					
Jan. 18-19	1846-0106	.171	110	0.40	9
Jan. 24	0018-1136	.235	100	0.50	C
Feb. 28 - Mar. 1	1800-0438	.301	96	0.62	C
Mar. 16	1702-2040	.077	69	0.11	C
Mar. 23	2000-2346	.134	61	0.17	C
Manganese, total recoverable (µg/L)					
1982					
Sept. 24	0342-0550	0.028	300	0.18	7
Oct. 25	0258-0432	.010	160	0.03	5
Oct. 26	0214-0512	.173	90	0.34	7
1983					
Jan. 18-19	1846-0106	.171	30	0.12	9
Jan. 24	0018-1136	.235	50	0.25	C
Feb. 28 - Mar. 1	1800-0438	.301	120	0.77	C
Mar. 16	1702-2040	.077	30	0.05	C
Mar. 23	2000-2346	.134	30	0.08	C
Mercury, total recoverable (µg/L)					
1981					
Nov. 12-13	2012-0040	0.041	0.1	<0.01	6
Nov. 17	0440-0756	.044	0.1	<0.01	3
1982					
Mar. 25-26	2236-0240	.031	0.1	<0.01	6
Sept. 24	0342-0550	.028	0.3	<0.01	7
Oct. 25	0258-0432	.010	1.6	<0.01	5
Oct. 26	0214-0512	.173	0.6	<0.01	7
Dec. 22	1500-1732	.124	2.4	0.01	C
Mercury, total recoverable (µg/L)--Continued					
1983					
Jan. 18-19	1846-0106	0.171	0.2	<0.01	9
Nickel, total recoverable (µg/L)					
1981					
Nov. 12-13	2012-0040	0.041	9.5	0.01	6
Nov. 17	0440-0756	.044	10	0.01	3
1982					
Mar. 25-26	2236-0240	.031	14	0.01	6
Mar. 31	1648-2320	.234	2.6	0.01	9
Sept. 24	0342-0550	.028	56	0.03	6
Oct. 25	0258-0432	.010	30	0.01	5
Oct. 26	0214-0512	.173	19	0.07	7
1983					
Jan. 18-19	1846-0106	.171	6.3	0.02	9
Jan. 24	0018-1136	.235	15	0.08	C
Feb. 28 - Mar. 1	1800-0438	.301	11	0.07	C
Mar. 16	1702-2040	.077	14	0.02	C
Mar. 23	2000-2346	.134	6.0	0.02	C
Zinc, total recoverable (µg/L)					
1981					
Nov. 12-13	2012-0040	0.041	190	0.17	6
Nov. 17	0440-0756	.044	160	0.15	3
1982					
Mar. 25-26	2236-0240	.031	90	0.06	6
Mar. 31	1648-2320	.234	60	0.29	9
1983					
Jan. 24	0018-1136	.235	80	0.40	C
Feb. 28 - Mar. 1	1800-0438	.301	120	0.77	C
Mar. 16	1702-2040	.077	60	0.10	C
Mar. 23	2000-2346	.134	60	0.17	C
Oxygen demand, chemical, 0.25 N dichromate (mg/L)					
1981					
Nov. 12-13	2012-0040	0.041	170	152	5
Nov. 17	0440-0756	.044	76	71	3
1982					
Mar. 25-26	2236-0240	.031	130	85	6
Mar. 31	1648-2320	.234	73	366	8
Dec. 22	1500-1732	.124	37	98	C
1983					
Jan. 24	0018-1136	.235	47	235	C
Feb. 28 - Mar. 1	1800-0438	.301	27	173	C
Mar. 16	1702-2040	.077	110	499	C
Mar. 16	1702-2040	.077	48	79	C
Mar. 23	2000-2346	.134	42	120	C

Table 19. Constituent storm-runoff loads: Single-dwelling residential catchment—Continued

Date	Time	Total runoff volume	EMC	Event load	n
Solids, sum of constituents, dissolved (mg/L)					
1981					
Nov. 12-13	2012-0040	0.041	60	52	6
Nov. 17	0440-0756	.044	38	36	3
1982					
Mar. 25-26	2236-0240	.031	37	24	6
Mar. 31	1648-2320	.234	18	91	9
Sept. 24	0342-0550	.028	93	56	7
Oct. 25	0258-0432	.010	56	12	6
Oct. 26	0214-0512	.173	23	85	7
Dec. 21	1818-2340	.047	27	27	e5
Dec. 22	1500-1732	.124	15	40	C
1983					
Jan. 18-19	1846-0106	.171	21	77	9
Jan. 21-22	2236-0110	.014	35	10	e3
Jan. 22	0510-1354	.173	23	85	e29
Jan. 24	0018-1136	.235	44	220	C
Jan. 28-29	2206-0418	.097	25	52	e9
Feb. 6-7	0720-0000	.138	25	73	e11
Feb. 7-8	2152-0104	.113	17	40	e11
Feb. 25	1434-1802	.023	44	22	e4
Feb. 28 - Mar. 1	1800-0438	.301	17	109	C
Mar. 23	2000-2346	.134	21	60	C
Sediment, suspended (mg/L)					
1981					
Nov. 12-13	2012-0040	0.041	106	93	6
Nov. 17	0440-0756	.044	216	202	3
1982					
Mar. 25-26	2236-0240	.031	22	14	6
Mar. 31	1648-2320	.234	36	178	9
Sept. 24	0342-0550	.028	538	321	7
Oct. 25	0258-0432	.010	307	65	6
Oct. 26	0214-0512	.173	392	1,440	7
Dec. 22	1500-1732	.124	136	359	C
Sediment, suspended (mg/L)--Continued					
1983					
Jan. 18-19	1846-0106	0.171	43	156	9
Jan. 24	0018-1136	.235	71	355	C
Feb. 28 - Mar. 1	1800-0438	.301	70	448	C
Mar. 16	1702-2040	.077	36	59	C
Mar. 23	2000-2346	.134	30	86	C
Carbon, organic, dissolved (mg/L)					
1981					
Nov. 12-13	2012-0040	0.041	76	66	6
Nov. 17	0440-0756	.044	140	128	3
1982					
Mar. 25-26	2236-0240	.031	100	66	6
Mar. 31	1648-2320	.234	150	747	9
Mar. 22	1500-1732	.124	50	132	C
1983					
Jan. 24	0018-1136	.235	20	101	C
Feb. 28 - Mar. 1	1800-0438	.301	4.4	28	C
Mar. 16	1702-2040	.077	45	74	C
Mar. 23	2000-2346	.134	27	77	C
Carbon, organic, suspended (mg/L)					
1981					
Nov. 12-13	2012-0040	0.041	3.2	2.8	4
Nov. 17	0440-0756	.044	9.3	8.7	3
1982					
Mar. 25-26	2236-0240	.031	1.4	0.95	6
Mar. 31	1648-2320	.234	1.5	7.7	9
Dec. 22	1500-1732	.124	5.0	13	C
1983					
Feb. 28 - Mar. 1	1800-0438	.301	1.9	12	C
Mar. 16	1702-2040	.077	3.6	5.9	C
Mar. 23	2000-2346	.134	2.3	6.6	C

Table 20. Constituent storm-runoff loads: Multiple-dwelling residential catchment

[Time is beginning and end of runoff, in hours. Total runoff volume is depth in inches covering the catchment drainage area. EMC is event mean concentration of constituent, in milligrams per liter (mg/L) or micrograms per liter (μg/L), as noted. Event load is in pounds. n is number of samples used in computation of storm-runoff load. Sample concentrations were determined by laboratory analyses except where noted by an e, which indicates sample concentrations were estimated using a regression equation. Composite samples are identified by a C. <, actual value is less than value shown]

Date	Time	Total runoff volume	EMC	Event load	n
Nitrogen, ammonia plus organic, dissolved (mg/L as N)					
1981					
Oct. 28	0705-1105	0.155	7.4	12	6
Nov. 12-13	2008-0100	.045	4.6	2.2	5
Nov. 17	0416-0800	.060	1.4	0.89	4
Dec. 29-30	1452-0408	.079	1.3	1.1	C
1982					
Jan. 4	0804-2008	.289	0.89	2.7	10
Jan. 4-5	2110-0304	.140	0.68	1.0	e7
Jan. 19-20	2224-0052	.045	2.1	0.99	e5
Jan. 20	0834-1306	.052	1.7	0.92	e6
Jan. 21	1422-1622	.058	1.0	0.61	e5
Feb. 14-15	1812-0130	.074	3.2	2.5	C
Feb. 15-16	2022-0710	.156	2.5	4.1	C
Mar. 9	1942-2320	.028	3.2	0.95	3
Mar. 10	0132-0700	.113	1.2	1.4	6
Mar. 10-11	2338-0900	.096	1.0	1.0	5
Mar. 14	0542-1550	.428	0.97	4.3	e26
Mar. 16	0652-1316	.153	1.1	1.8	e13
Mar. 25-26	2224-0348	.064	2.0	1.3	5
Mar. 29	1154-1700	.092	1.3	1.2	C
Mar. 29	1704-2024	.042	1.0	0.44	C
Apr. 10	1132-1444	.059	2.1	1.3	e6
Apr. 10	1908-2332	.083	1.8	1.6	e7
Sept. 24	0330-0658	.069	7.1	5.1	10
Oct. 26	0216-0602	.528	4.3	24	7
Oct. 30	0130-0956	.242	1.2	3.1	e22
Nov. 9	1204-1744	.170	1.4	2.5	C
Nov. 18	0744-1212	.130	1.4	1.8	e13
1983					
Jan. 18-19	1838-0204	.462	1.5	7.1	10
Jan. 24	0018-1422	.598	0.90	5.6	C
Jan. 28-29	2206-0552	.262	0.33	0.90	e11
Feb. 7-8	2154-0320	.349	0.43	1.6	e14
Feb. 12-13	1246-0006	.100	1.8	1.9	e6
Feb. 18	0720-1018	.122	1.4	1.8	e11
Feb. 28 - Mar. 1	1652-0626	.900	0.20	1.9	C
Mar. 16	1704-2218	.213	0.90	2.0	C
Mar. 23-24	1958-0052	.503	0.90	4.7	C
Nitrogen, nitrite plus nitrate, dissolved (mg/L as N)					
1981					
Oct. 28	0705-1105	0.155	2.2	3.6	6
Nov. 12-13	2008-0100	.045	1.1	0.53	5
Nov. 17	0416-0800	.060	0.35	0.22	4
Nitrogen, nitrite plus nitrate, dissolved (mg/L as N)--Continued					
1981					
Dec. 29-30	1452-0408	0.079	0.41	0.34	C
1982					
Jan. 4	0804-2008	.289	0.20	0.59	10
Jan. 4-5	2110-0304	.140	0.13	0.20	e7
Jan. 19-20	2224-0052	.045	0.51	0.24	e5
Jan. 20	0834-1306	.052	0.37	0.20	e6
Jan. 21	1422-1622	.058	0.16	0.09	e5
Feb. 14-15	1812-0130	.074	0.42	0.32	C
Feb. 15-16	2022-0710	.156	0.30	0.49	C
Mar. 9	1942-2320	.028	0.68	0.20	3
Mar. 10	0132-0700	.113	0.28	0.33	6
Mar. 10-11	2338-0900	.096	0.26	0.26	5
Mar. 14	0542-1550	.428	0.22	0.98	e26
Mar. 16	0652-1316	.153	0.26	0.42	e13
Mar. 25-26	2224-0348	.064	0.68	0.45	5
Mar. 29	1154-1700	.092	0.29	0.28	C
Mar. 29	1704-2024	.042	0.19	0.08	C
Apr. 10	1132-1444	.059	0.50	0.31	e6
Apr. 10	1908-2332	.083	0.41	0.36	e7
Sept. 24	0330-0658	.069	2.1	1.5	10
Oct. 26	0216-0602	.528	0.22	1.2	7
Oct. 30	0130-0956	.242	0.22	0.56	e22
Nov. 9	1204-1744	.170	0.36	0.64	C
Nov. 18	0744-1212	.130	0.26	0.36	e13
1983					
Jan. 18-19	1838-0204	.462	0.26	1.3	10
Jan. 24	0018-1422	.598	0.17	1.1	C
Fet. 12-13	1246-0006	.100	0.40	0.42	e6
Feb. 18	0720-1018	.122	0.27	0.35	e11
Feb. 28 - Mar. 1	1652-0626	.900	0.13	1.2	C
Mar. 16	1704-2218	.213	0.83	1.8	C
Mar. 23-24	1958-0052	.503	0.16	0.84	C
Phosphorus, dissolved (mg/L as P)					
1981					
Oct. 28	0705-1105	0.155	0.82	1.3	7
Nov. 12-13	2008-0100	.045	0.63	0.30	5
Nov. 17	0416-0800	.060	0.23	0.14	4
Dec. 29-30	1452-0408	.079	0.24	0.19	e13
1982					
Jan. 4	0804-2008	.289	0.21	0.64	10
Jan. 4-5	2110-0304	.140	0.11	0.17	e7
Jan. 19-20	2224-0052	.045	0.29	0.13	e5

Table 20. Constituent storm-runoff loads: Multiple-dwelling residential catchment—Continued

Date	Time	Total runoff volume	EMC	Event load	n
Phosphorus, dissolved (mg/L as P)--Continued					
1982					
Jan. 20	0834-1306	0.052	0.25	0.14	e6
Jan. 21	1422-1622	.058	0.19	0.11	e5
Feb. 14-15	1812-0130	.074	0.43	0.33	C
Feb. 15-16	2022-0710	.156	0.14	0.22	C
Mar. 9	1942-2320	.028	0.32	0.10	3
Mar. 10	0132-0700	.113	0.12	0.14	6
Mar. 10-11	2338-0900	.096	0.23	0.23	5
Mar. 14	0542-1550	.428	0.15	0.65	e26
Mar. 16	0652-1316	.153	0.16	0.26	e13
Mar. 25-26	2224-0348	.064	0.23	0.15	5
Mar. 29	1154-1700	.092	0.11	0.11	C
Mar. 29	1704-2024	.042	0.12	0.05	C
Apr. 10	1132-1444	.059	0.29	0.18	e6
Apr. 10	1908-2332	.083	0.26	0.22	e7
Sept. 24	0330-0658	.069	0.73	0.53	10
Oct. 26	0216-0602	.528	0.19	1.1	7
Oct. 30	0130-0956	.242	0.21	0.52	e22
Nov. 9	1204-1744	.170	0.20	0.36	C
Nov. 18	0744-1212	.130	0.22	0.30	e13
1983					
Jan. 18-19	1838-0204	.462	0.32	1.6	10
Jan. 24	0018-1422	.598	0.08	0.50	C
Jan. 28-29	2206-0552	.262	0.13	0.35	e11
Feb. 7-8	2154-0320	.349	0.14	0.50	e14
Feb. 12-13	1246-0006	.100	0.26	0.27	e6
Feb. 18	0720-1018	.122	0.22	0.28	e11
Feb. 28- Mar. 1	1652-0626	.900	0.06	0.56	C
Mar. 16	1704-2218	.213	0.15	0.33	C
Mar. 23-24	1958-0052	.503	0.08	0.42	C
Aluminum, total recoverable (µg/L)					
1982					
Nov. 9	1204-1744	0.170	2,800	5.0	C
1983					
Jan. 24	0018-1422	.598	4,400	27	C
Feb. 28 - Mar. 1	1652-0626	.900	2,700	25	C
Mar. 16	1704-2218	.213	3,200	7.1	C
Mar. 23-24	1958-0052	.503	1,600	8.4	C
Arsenic, total (µg/L)					
1981					
Oct. 28	0705-1105	0.155	8	0.01	6
Nov. 12-13	2008-0100	.045	5	<0.01	5
Nov. 17	0416-0800	.060	2	<0.01	4
Dec. 29-30	1452-0408	.079	2	<0.01	C
1982					
Feb. 14-15	1812-0130	.074	2	<0.01	C
Feb. 15-16	2022-0710	.156	1	<0.01	C
Mar. 10	0132-0700	.113	2	<0.01	5
Mar. 29	1154-1700	.092	2	<0.01	C
Arsenic, total (µg/L)--Continued					
1982					
Mar. 29	1704-2024	0.042	1	<0.01	C
Sept. 24	0330-0658	.069	4	<0.01	10
Oct. 26	0216-0602	.528	2	0.01	7
Nov. 9	1204-1744	.170	2	<0.01	C
1983					
Jan. 18-19	1838-0204	.462	1	0.01	9
Feb. 28 - Mar. 1	1652-0626	.900	1	0.01	C
Mar. 16	1704-2218	.213	1	<0.01	C
Mar. 23-24	1958-0052	.503	1	0.01	C
Chromium, total recoverable (µg/L)					
1981					
Oct. 28	0705-1105	0.155	12	0.02	6
Nov. 12-13	2008-0100	.045	21	0.01	5
Nov. 17	0416-0800	.060	28	0.02	4
Dec. 29-30	1452-0408	.079	25	0.02	C
1982					
Jan. 4	0804-2008	.289	22	0.07	10
Feb. 14-15	1812-0130	.074	10	0.01	C
Feb. 15-16	2022-0710	.156	10	0.02	C
Mar. 9	1942-2320	.028	10	<0.01	3
Mar. 10	0132-0700	.113	23	0.03	5
Mar. 10-11	2338-0900	.096	18	0.02	5
Mar. 25-26	2224-0348	.064	10	0.01	5
Mar. 29	1154-1700	.092	16	0.02	C
Mar. 29	1704-2024	.042	16	0.01	C
Nov. 9	1204-1744	.170	18	0.03	C
1983					
Jan. 24	0018-1422	.598	10	0.06	C
Feb. 28 - Mar. 1	1652-0626	.900	8	0.08	C
Mar. 16	1704-2218	.213	10	0.02	C
Mar. 23	1958-0052	.503	6	0.03	C
Copper, total recoverable (µg/L)					
1981					
Oct. 28	0705-1105	0.155	100	0.17	6
Nov. 12-13	2008-0100	.045	35	0.02	5
Nov. 17	0416-0800	.060	27	0.02	4
Dec. 29-30	1452-0408	.079	24	0.02	C
1982					
Jan. 4	0804-2008	.289	24	0.07	10
Feb. 14-15	1812-0130	.074	33	0.02	C
Feb. 15-16	2022-0710	.156	12	0.02	C
Mar. 9	1942-2320	.028	17	0.01	3
Mar. 10	0132-0700	.113	30	0.03	5
Mar. 10-11	2338-0900	.096	27	0.03	5
Mar. 25-26	2224-0348	.064	16	0.01	5
Mar. 29	1154-1700	.092	11	0.01	C
Mar. 29	1704-2024	.042	12	0.01	C
Nov. 9	1204-1744	.170	11	0.02	C

Table 20. Constituent storm-runoff loads: Multiple-dwelling residential catchment—Continued

Date	Time	Total runoff volume	EMC	Event load	n
Copper, total recoverable (µg/L)--Continued					
1983					
Jan. 24	0018-1422	0.598	14	0.09	C
Feb. 28 - Mar. 1	1652-0626	.900	9	0.08	C
Mar. 16	1704-2218	.213	10	0.02	C
Mar. 23-24	1958-0052	.503	9	0.05	C
Iron, total recoverable (µg/L)					
1981					
Oct. 28	0705-1105	0.155	33,000	54	6
Nov. 12-13	2008-0100	.045	7,000	3.3	5
Nov. 17	0416-0800	.060	15,000	9.4	4
Dec. 29-30	1452-0408	.079	9,400	7.7	C
1982					
Jan. 4	0804-2008	.289	7,900	24	10
Feb. 14-15	1812-0130	.074	3,800	3.0	C
Feb. 15-16	2022-0710	.156	3,400	5.5	C
Mar. 9	1942-2320	.028	3,000	0.88	3
Mar. 10	0132-0700	.113	11,000	13	5
Mar. 10-11	2338-0900	.096	7,700	7.7	5
Mar. 25-26	2224-0348	.064	2,600	1.7	5
Mar. 29	1154-1700	.092	3,600	3.5	C
Mar. 29	1704-2024	.042	4,700	2.1	C
Sept. 24	0330-0658	.069	29,000	21	10
Oct. 26	0216-0602	.528	27,000	148	9
Nov. 9	1204-1744	.170	3,600	6.4	C
1983					
Jan. 18-19	1838-0204	.462	5,400	26	10
Jan. 24	0018-1422	.598	6,000	38	C
Feb. 28 - Mar. 1	1652-0626	.900	3,800	36	C
Mar. 16	1704-2218	.213	4,100	9.1	C
Mar. 23-24	1958-0052	.503	2,500	13	C
Lead, total recoverable (µg/L)					
1981					
Oct. 28	0705-1105	0.155	670	1.1	6
Nov. 12-13	2008-0100	.045	150	0.07	5
Nov. 17	0416-0800	.060	190	0.12	4
Dec. 29-30	1452-0408	.079	240	0.20	C
1982					
Jan. 4	0804-2008	.289	220	0.66	10
Feb. 14-15	1812-0130	.074	170	0.13	C
Feb. 15-16	2022-0710	.156	89	0.14	C
Mar. 9	1942-2320	.028	120	0.04	3
Mar. 10	0132-0700	.113	350	0.41	5
Mar. 10-11	2338-0900	.096	230	0.23	5
Mar. 25-26	2224-0348	.064	80	0.05	5
Mar. 29	1154-1700	.092	110	0.11	C
Mar. 29	1704-2024	.042	140	0.06	C
Sept. 24	0330-0658	.069	490	0.35	10
Oct. 26	0216-0602	.528	260	1.5	9
Nov. 9	1204-1744	.170	120	0.21	C
Lead, total recoverable (µg/L)--Continued					
1983					
Jan. 18-19	1838-0204	0.462	170	0.83	10
Jan. 24	0018-1422	.598	130	0.81	C
Feb. 28 - Mar. 1	1652-0626	.900	95	0.89	C
Mar. 16	1704-2218	.213	83	0.18	C
Mar. 23-24	1958-0052	.503	63	0.33	C
Manganese, total recoverable (µg/L)					
1982					
Sept. 24	0330-0658	0.069	840	0.60	10
Oct. 24	0216-0602	.528	520	2.8	9
Nov. 9	1204-1744	.170	80	0.14	C
1983					
Jan. 18-19	1838-0204	.462	120	0.57	10
Jan. 24	0018-1422	.598	120	0.75	C
Feb. 28 - Mar. 1	1652-0626	.900	90	0.84	C
Mar. 16	1704-2218	.213	90	0.20	C
Mar. 23-24	1958-0052	.503	60	0.32	C
Mercury, total recoverable (µg/L)					
1981					
Oct. 28	0705-1105	0.155	0.8	<0.01	6
Nov. 12-13	2008-0100	.045	0.5	<0.01	5
Nov. 17	0416-0800	.060	0.3	<0.01	4
Dec. 29-30	1452-0408	.079	0.2	<0.01	C
1982					
Jan. 4	0804-2008	.289	0.2	<0.01	10
Feb. 14-15	1812-0130	.074	1.3	<0.01	C
Feb. 15-16	2022-0710	.156	0.7	<0.01	C
Mar. 9	1942-2320	.028	0.3	<0.01	3
Mar. 10	0132-0700	.113	0.3	<0.01	5
Mar. 10-11	2338-0900	.096	0.2	<0.01	5
Mar. 25-26	2224-0348	.064	0.2	<0.01	5
Mar. 29	1154-1700	.092	0.1	<0.01	C
Mar. 29	1704-2024	.042	0.1	<0.01	C
Sept. 24	0330-0658	.069	0.6	<0.01	10
Oct. 26	0216-0602	.528	0.4	<0.01	7
Nov. 9	1204-1744	.170	0.2	<0.01	C
1983					
Jan. 18-19	1838-0204	.462	0.2	<0.01	9
Jan. 24	0018-1422	.598	0.1	<0.01	C
Feb. 28- Mar. 1	1652-0626	.900	0.2	<0.01	C
Mar. 16	1704-2218	.213	0.1	<0.01	C
Nickel, total recoverable (µg/L)					
1981					
Oct. 28	0705-1105	0.155	120	0.19	6
Nov. 12-13	2008-0100	.045	24	0.01	5
Nov. 17	0416-0800	.060	31	0.02	4
Dec. 29-30	1452-0408	.079	18	0.02	C

Table 20. Constituent storm-runoff loads: Multiple-dwelling residential catchment—Continued

Nickel, total recoverable (µg/L)--Continued

Date	Time	Total runoff volume	EMC	Event load	n
1982					
Jan. 4	0804-2008	0.289	17	0.05	10
Feb. 14-15	1812-0130	.074	14	0.01	C
Feb. 15-16	2022-0710	.156	11	0.02	C
Mar. 9	1942-2320	.028	5	<0.01	3
Mar. 10	0132-0700	.113	10	0.01	5
Mar. 10-11	2338-0900	.096	19	0.02	5
Mar. 25-26	2224-0348	.064	21	0.01	5
Mar. 29	1154-1700	.092	10	0.01	C
Mar. 29	1704-2024	.042	13	0.01	C
Sept. 24	0330-0658	.069	110	0.08	10
Oct. 26	0216-0602	.528	82	0.45	9
Nov. 9	1204-1744	.170	13	0.02	C
1983					
Jan. 18-19	1838-0204	.462	20	0.10	10
Jan. 24	0018-1422	.598	20	0.12	C
Feb. 28-Mar. 1	1652-0626	.900	13	0.12	C
Mar. 16	1704-2218	.213	24	0.05	C
Mar. 23	1958-0052	.503	10	0.05	C

Zinc, total recoverable (µg/L)

Date	Time	Total runoff volume	EMC	Event load	n
1981					
Oct. 28	0705-1105	0.155	1,100	1.7	6
Nov. 12-13	2008-0100	.045	240	0.11	5
Nov. 17	0416-0800	.060	230	0.14	4
Dec. 29-30	1452-0408	.079	220	0.18	C
1982					
Jan. 4	0804-2008	.289	190	0.58	10
Feb. 14-15	1812-0130	.074	170	0.13	C
Feb. 15-16	2022-0710	.156	110	0.18	C
Mar. 9	1942-2320	.028	150	0.04	3
Mar. 10	0132-0700	.113	290	0.34	5
Mar. 10-11	2338-0900	.096	170	0.17	5
Mar. 25-26	2224-0348	.064	120	0.08	5
Mar. 29	1154-1700	.092	110	0.11	C
Mar. 29	1704-2024	.042	110	0.05	C
Nov. 9	1204-1744	.170	130	0.23	C
1983					
Jan. 24	0018-1422	.598	120	0.75	C
Feb. 28 - Mar. 1	1652-0626	.900	80	0.75	C
Mar. 16	1704-2218	.213	140	0.31	C
Mar. 23-24	1958-0052	.503	70	0.37	C

Oxygen demand, chemical, 0.25 N dichromate (mg/L)

Date	Time	Total runoff volume	EMC	Event load	n
1981					
Oct. 28	0705-1105	0.155	470	757	8
Nov. 12-13	2008-0100	.045	180	84	5
Nov. 17	0416-0800	.060	74	46	4
Dec. 29-30	1452-0408	.079	100	83	C

Oxygen demand, chemical, 0.25 N dichromate (mg/L)--Continued

Date	Time	Total runoff volume	EMC	Event load	n
1982					
Jan. 4	0804-2008	0.289	54	163	10
Feb. 14-15	1812-0130	.074	110	85	C
Feb. 15-16	2022-0710	.156	49	80	C
Mar. 9	1942-2320	.028	110	31	3
Mar. 10	0132-0700	.113	80	95	6
Mar. 10-11	2338-0900	.096	96	97	5
Mar. 25-26	2224-0348	.064	110	73	5
Mar. 29	1154-1700	.092	71	68	C
Mar. 29	1704-2024	.042	68	30	C
Nov. 9	1204-1744	.170	77	137	C
1983					
Jan. 24	0018-1422	.598	56	350	C
Feb. 28-Mar. 1	1652-0626	.900	43	404	C
Mar. 16	1704-2218	.213	110	245	C
Mar. 23-24	1958-0052	.503	38	200	C

Solids, sum of constituents, dissolved (mg/L)

Date	Time	Total runoff volume	EMC	Event load	n
1981					
Oct. 28	0705-1105	0.155	83	135	6
Nov. 12-13	2008-0100	.045	74	35	5
Nov. 17	0416-0800	.060	38	24	4
Dec. 29-30	1452-0408	.079	35	29	C
1982					
Jan. 4	0804-2008	.289	27	81	10
Jan. 4-5	2110-0304	.140	21	30	e7
Jan. 19-20	2224-0052	.045	35	16	e5
Jan. 20	0834-1306	.052	30	16	e6
Jan. 21	1422-1622	.058	23	14	e5
Feb. 14-15	1812-0130	.074	40	31	C
Feb. 15-16	2022-0710	.156	30	49	C
Mar. 9	1942-2320	.028	39	11	3
Mar. 10	0132-0700	.113	24	28	e13
Mar. 10-11	2338-0900	.096	28	29	5
Mar. 14	0542-1550	.428	24	106	e26
Mar. 16	0652-1316	.153	25	41	e13
Mar. 25-26	2224-0348	.064	34	22	5
Mar. 29	1154-1700	.092	40	38	C
Mar. 29	1704-2024	.042	30	13	e11
Apr. 10	1132-1444	.059	35	22	e6
Apr. 10	1908-2332	.083	32	27	e7
Sept. 24	0330-0658	.069	82	58	10
Oct. 26	0216-0602	.528	30	164	9
Oct. 30	0130-0956	.242	25	64	e22
Nov. 9	1204-1744	.170	27	48	C
Nov. 18	0744-1212	.130	27	36	e13
1983					
Jan. 18	1838-0204	.462	27	129	10
Jan. 24	0018-1422	.598	24	150	C

Table 20. Constituent storm-runoff loads: Multiple-dwelling residential catchment—Continued

Date	Time	Total runoff volume	EMC	Event load	n
Solids, sum of constituents, dissolved (mg/L)--Continued					
1983					
Jan. 28-29	2206-0552	0.262	16	43	e11
Feb. 7-8	2154-0320	.349	17	61	e14
Feb. 12-13	1246-0006	.100	31	33	e6
Feb. 18	0720-1018	.122	27	34	e11
Feb. 28 - Mar. 1	1652-0626	.900	21	197	C
Mar. 23-24	1958-0052	.503	16	84	C
Sediment, suspended (mg/L)					
1981					
Dec. 29-30	1452-0408	0.079	485	400	C
1982					
Feb. 14-15	1812-0130	.074	112	87	C
Feb. 15-16	2022-0710	.156	144	235	C
Mar. 29	1154-1700	.092	199	191	C
Mar. 29	1704-2024	.042	200	88	C
Sept. 24	0330-0658	.069	1,910	1,370	10
Oct. 26	0216-0602	.528	924	5,090	7
Nov. 9	1204-1744	.170	421	747	C
1983					
Jan. 18-19	1838-0204	.462	673	3,250	9
Jan. 24	0018-1422	.598	234	1,460	C
Feb. 28 - Mar. 1	1652-0626	.900	145	1,360	C
Mar. 16	1704-2218	.213	132	294	C
Mar. 23-24	1958-0052	.503	91	479	C
Carbon, organic, dissolved (mg/L)					
1981					
Oct. 28	0705-1105	0.155	94	152	7
Dec. 29-30	1452-0408	.079	9.8	8.1	C
1982					
Jan. 4	0804-2008	.289	9.0	27	10
Feb. 14-15	1812-0130	.074	23	18	C
Carbon, organic, dissolved (mg/L)--Continued					
1982					
Feb. 15-16	2022-0710	0.156	26	42	C
Mar. 9	1942-2320	.028	45	13	3
Mar. 10	0132-0700	.113	6.6	7.8	6
Mar. 10-11	2338-0900	.096	61	61	5
Mar. 25-26	2224-0348	.064	120	77	5
Mar. 29	1154-1700	.092	120	115	C
Mar. 29	1704-2024	.042	270	118	C
Nov. 9	1204-1744	.170	11	20	C
1983					
Jan. 24	0018-1422	.598	10	63	C
Feb. 28 - Mar. 1	1652-0626	.900	8.2	94	C
Mar. 16	1704-2218	.213	33	73	C
Mar. 23-24	1958-0052	.503	24	126	C
Carbon, organic, suspended (mg/L)					
1981					
Oct. 28	0705-1105	0.155	3.7	5.9	7
Dec. 29-30	1452-0408	.079	3.5	2.9	C
1982					
Jan. 4	0804-2008	.289	2.9	8.8	10
Feb. 15-16	2022-0710	.156	2.8	4.6	C
Mar. 9	1942-2320	.028	2.7	0.79	3
Mar. 10	0132-0700	.113	5.1	6.0	5
Mar. 10-11	2338-0900	.096	3.6	3.6	5
Mar. 25-26	2224-0348	.064	1.9	1.3	5
Mar. 29	1154-1700	.092	2.1	2.0	C
Mar. 29	1704-2024	.042	2.2	0.97	C
Nov. 9	1204-1744	.170	3.5	0.62	C
Jan. 24	0018-1422	.598	2.1	2.0	C
Feb. 28- Mar. 1	1652-0626	.900	3.7	35	C
Mar. 16	1704-2218	.213	3.7	8.2	C
Mar. 23-24	1958-0052	.503	3.1	16	C

Table 21. Constituent storm-runoff loads: Commercial catchment

[Time is beginning and end of runoff, in hours. Total runoff volume is depth in inches covering the catchment drainage area. EMC is event mean concentration of constituent, in milligrams per liter (mg/L) or micrograms per liter (µg/L), as noted. Event load is in pounds. n is number of samples used in computation of storm-runoff load. Sample concentrations were determined by laboratory analyses except where noted by an e, which indicates sample concentration were estimated using a regression equation. Composite samples are identified by a C. <, actual value is less than value shown]

Nitrogen, ammonia plus organic, dissolved (mg/L as N)

Date	Time	Total runoff volume	EMC	Event load	n
1981					
Nov. 17	0416-0816	0.234	1.6	5.1	7
Dec. 29-30	1452-0444	.314	1.3	5.7	C
1982					
Jan. 4	0754-2100	.772	0.78	8.4	13
Jan. 21	1348-1718	.206	0.95	2.7	e10
Feb. 14-15	2048-1032	.263	1.8	6.6	C
Feb. 15-16	2020-1002	.459	2.0	13	C
Mar. 9	1928-2344	.151	3.2	6.8	4
Mar. 10-11	2316-0330	.285	0.98	3.9	3
Mar. 11	1030-2040	.201	1.3	3.7	e17
Mar. 14	0342-1630	.959	1.0	13	e35
Mar. 16	0600-1338	.439	1.2	7.6	e21
Mar. 16-17	2002-0222	.320	1.1	4.8	e13
Mar. 18	0414-0956	.211	1.4	4.2	e9
Mar. 18	1330-1600	.151	2.0	4.1	e7
Mar. 25-26	2238-0250	.148	2.1	4.3	5
Mar. 29	1220-1658	.210	0.96	2.8	C
Mar. 29	1700-1910	.101	0.80	1.1	C
Apr. 10	0516-0934	.174	1.9	4.5	e9
Apr. 10	1124-1434	.159	1.3	2.8	e6
Apr. 10-11	1914-0020	.231	0.95	3.1	e9
Sept. 24	0234-0812	.231	9.0	26	13
Oct. 25	0256-0518	.052	8.3	5.5	6
Oct. 26	0148-0626	.600	6.1	46	7
Nov. 8	1726-2028	.130	3.4	5.6	C
Nov. 9	1030-1850	.460	1.5	8.7	C
1983					
Jan. 18-19	1716-0134	.969	0.97	13	10
Jan. 24	0018-1336	.840	0.80	9.4	C
Feb. 28- Mar. 1	1804-0832	1.22	0.70	12	C
Mar. 16	1654-2110	.429	1.0	6.0	C
Mar. 23-24	1958-0308	.620	1.1	9.6	C

Nitrogen, nitrite plus nitrate, dissolved (mg/L as N)

Date	Time	Total runoff volume	EMC	Event load	n
1981					
Nov. 17	0416-0816	0.234	0.36	1.2	7
Dec. 29-30	1452-0444	.314	0.91	4.0	C
1982					
Jan. 4	0754-2100	.772	0.23	2.5	13
Jan. 21	1348-1718	.206	0.25	0.72	e10
Feb. 14-15	2048-1032	.263	0.42	1.5	C
Feb. 15-16	2020-1002	.459	0.24	1.5	C
Mar. 9	1928-2344	0.151	0.87	1.8	4
Mar. 10-11	2316-0330	.285	0.26	1.1	3
Mar. 11	1030-2040	.201	0.38	1.1	e17
Mar. 14	0342-1630	.959	0.27	3.6	e35
Mar. 16	0600-1338	.439	0.35	2.1	e21
Mar. 16-17	2002-0222	.320	0.29	1.3	e13
Mar. 18	0414-0956	.211	0.41	1.2	e9
Mar. 18	1330-1600	.151	0.60	1.3	e7
Mar. 25-26	2238-0250	.148	0.63	1.3	5
Mar. 29	1220-1658	.210	0.23	0.67	C
Mar. 29	1700-1910	.101	0.18	0.25	C
Apr. 10	0516-0934	.174	0.56	1.4	e9
Apr. 10	1124-1434	.159	0.36	0.81	e6
Apr. 10-11	1914-0020	.231	0.25	0.81	e9
Sept. 24	0234-0812	.231	3.6	11	13
Oct. 25	0256-0518	.052	1.9	1.2	6
Oct. 26	0148-0626	.600	0.47	3.6	7
Nov. 8	1726-2028	.130	1.1	1.8	C
Nov. 9	1030-1850	.460	0.29	1.7	C
1983					
Jan. 18-19	1716-0134	.969	0.18	2.5	10
Jan. 24	0018-1336	.840	0.18	2.1	C
Feb. 28 - Mar. 1	1804-0832	1.22	0.12	2.1	C
Mar. 16	1654-2110	.429	0.81	4.9	C
Mar. 23-24	1958-0308	.620	0.23	2.0	C

Phosphorus, dissolved (mg/L as P)

Date	Time	Total runoff volume	EMC	Event load	n
1981					
Nov. 17	0416-0816	0.234	0.11	0.36	7
Dec. 29-30	1452-0444	.314	0.36	1.6	C
1982					
Jan. 4	0754-2100	.772	0.08	0.88	13
Jan. 21	1348-1718	.206	0.08	0.22	e10
Feb. 14-15	2048-1032	.263	0.11	0.41	C
Feb. 15-16	2020-1002	.459	0.07	0.45	C
Mar. 9	1928-2344	.151	0.20	0.43	4
Mar. 10-11	2316-0330	.285	0.06	0.22	3
Mar. 11	1030-2040	.201	0.10	0.29	e17
Mar. 14	0342-1630	.959	0.08	1.1	e35
Mar. 16	0600-1338	.439	0.10	0.60	e21
Mar. 16-17	2002-0222	.320	0.08	0.38	e13
Mar. 18	0414-0956	.211	0.11	0.33	e9
Mar. 18	1330-1600	.151	0.15	0.33	e7
Mar. 25-26	2238-0250	0.148	0.16	0.34	5

best copy available

Table 21. Constituent storm-runoff loads: Commercial catchment—Continued

Phosphorus, dissolved (mg/L as P)--Continued

Date	Time	Total runoff volume	EMC	Event load	n
1982					
Mar. 29	1220-1658	.210	0.04	0.12	C
Mar. 29	1700-1910	.101	0.02	0.03	C
Apr. 10	0516-0934	.174	0.15	0.36	e9
Apr. 10	1124-1434	.159	0.10	0.22	e6
Apr. 10-11	1914-0020	.231	0.08	0.24	e9
Sept. 24	0234-0812	.231	0.65	1.9	13
Oct. 25	0256-0518	.052	0.22	0.14	6
Oct. 26	0148-0626	.600	0.18	1.4	7
Nov. 8	1726-2028	.130	0.12	0.20	C
Nov. 9	1030-1850	.460	0.05	0.29	C
1983					
Jan. 18-19	1716-0134	.969	0.15	2.0	10
Jan. 24	0018-1336	.840	0.25	2.9	C
Feb. 28-Mar. 1	1804-0832	1.22	0.02	0.34	C
Mar. 16	1654-2110	.429	0.05	0.30	C
Mar. 23-24	1958-0308	.620	0.06	0.52	C

Aluminum, total recoverable (µg/L)

Date	Time	Total runoff volume	EMC	Event load	n
1982					
Nov. 8	1726-2028	0.130	2,800	4.6	C
Nov. 9	1030-1850	.460	3,000	17	C
1983					
Jan. 24	0018-1336	.840	5,200	61	C
Feb. 28 - Mar. 1	1804-0832	1.22	120	2.1	C
Mar. 16	1654-2110	.429	6,300	38	C
Mar. 23-24	1958-0308	.620	3,400	30	C

Arsenic, total (µg/L)

Date	Time	Total runoff volume	EMC	Event load	n
1981					
Nov. 17	0416-0816	0.234	7	0.02	7
Dec. 29-30	1452-0444	.314	2	0.01	C
1982					
Jan. 4	0754-2100	.772	1	0.01	13
Feb. 14-15	2048-1032	.263	1	<0.01	C
Feb. 15-16	2020-1002	.459	1	0.01	C
Mar. 9	1928-2344	.151	11	0.02	3
Mar. 10-11	2316-0330	.285	2	0.01	3
Mar. 25-26	2238-0250	.148	1	<0.01	5
Mar. 29	1220-1658	.210	1	<0.01	C
Mar. 29	1700-1910	.101	1	<0.01	C
Sept. 24	0234-0812	.231	4	0.01	13
Oct. 25	0256-0518	.052	6	<0.01	6
Oct. 26	0148-0626	.600	3	0.02	7
Nov. 8	1726-2028	.130	17	0.03	C
Nov. 9	1030-1850	.460	2	0.01	C
1983					
Jan. 18-19	1716-0134	.969	2	0.03	10
Jan. 24	0018-1336	.840	1	0.01	C
Feb. 28-Mar. 1	1804-0832	1.22	11	<0.01	C
Mar. 16	1654-2110	.429	2	0.01	C
Mar. 23-24	1958-0308	.620	2	0.02	C

Chromium, total recoverable (µg/L)

Date	Time	Total runoff volume	EMC	Event load	n
1981					
Nov. 17	0416-0816	0.234	11	0.04	7
Dec. 29-30	1452-0444	.314	10	0.04	C
1982					
Jan. 4	0754-2100	.772	10	0.11	13
Feb. 14-15	2048-1032	.263	5	0.02	C
Feb. 15-16	2020-1002	.459	3	0.02	C
Mar. 9	1928-2344	.151	12	0.03	3
Mar. 10-11	2316-0330	.285	9	0.04	3
Mar. 25-26	2238-0250	.148	11	0.02	5
Mar. 29	1220-1658	.210	10	0.03	C
Mar. 29	1700-1910	.101	20	0.03	C
Nov. 8	1726-2028	.130	12	0.02	C
Nov. 9	1030-1850	.460	10	0.06	C
1983					
Jan. 24	0018-1336	.840	12	0.14	C
Feb. 28 - Mar. 1	1804-0832	1.22	3	0.05	C
Mar. 16	1654-2110	.429	23	0.14	C
Mar. 23-24	1958-0308	.620	13	0.11	C

Copper, total recoverable (µg/L)

Date	Time	Total runoff volume	EMC	Event load	n
1981					
Nov. 17	0416-0816	0.234	15	0.05	7
Dec. 29-30	1452-0444	.314	16	0.07	C
1982					
Jan. 4	0754-2100	.772	13	0.14	13
Feb. 14-15	2048-1032	.263	9	0.03	C
Feb. 15-16	2020-1002	.459	6	0.04	C
Mar. 9	1928-2344	.151	23	0.05	3
Mar. 10-11	2316-0330	.285	10	0.04	3
Mar. 25-26	2238-0250	.148	16	0.03	5
Mar. 29	1220-1658	.210	10	0.03	C
Mar. 29	1700-1910	.101	13	0.02	C
Nov. 8	1726-2028	.130	21	0.03	C
Nov. 9	1030-1850	.460	13	0.08	C
1983					
Jan. 24	0018-1336	.840	20	0.23	C
Feb. 28-Mar. 1	1804-0832	1.22	7	0.12	C
Mar. 16	1654-2110	.429	17	0.10	C
Mar. 23-24	1958-0308	.620	14	0.12	C

Iron, total recoverable (µg/L)

Date	Time	Total runoff volume	EMC	Event load	n
1981					
Nov. 17	0416-0816	0.234	1,400	4.5	7
Dec. 29-30	1452-0444	.314	1,200	5.3	C
1982					
Jan. 4	0754-2100	.772	910	9.8	13
Feb. 14-15	2048-1032	.263	430	1.6	C
Feb. 15-16	2020-1002	.459	520	3.4	C
Mar. 9	1928-2344	.151	1,200	2.5	3

Table 21. Constituent storm-runoff loads: Commercial catchment—Continued

Date	Time	Total runoff volume	EMC	Event load	n
Iron, total recoverable (µg/L)--Continued					
1982					
Mar. 10-11	2316-0330	0.285	940	3.8	3
Mar. 25-26	2238-0250	.148	790	1.6	5
Mar. 29	1220-1658	.210	1,100	3.2	C
Mar. 29	1700-1910	.101	2,500	3.5	C
Sept. 24	0234-0812	.231	22,000	65	13
Oct. 25	0256-0518	.052	11,000	7.1	6
Oct. 26	0148-0626	.600	7,900	60	7
Nov. 8	1726-2028	.130	4,200	6.9	C
Nov. 9	1030-1850	.460	4,400	26	C
1983					
Jan. 18-19	1716-0134	.969	10,000	136	10
Jan. 24	0018-1336	.840	7,200	84	C
Feb. 1 - Mar. 1	1804-0832	1.22	1,500	26	C
Mar. 16	1654-2110	.429	8,300	50	C
Mar. 23-24	1958-0308	.620	5,200	45	C
Lead, total recoverable (µg/L)					
1981					
Nov. 17	0416-0816	0.234	120	0.38	7
Dec. 29-30	1452-0444	.314	150	0.66	C
1982					
Jan. 4	0754-2100	.772	74	0.80	13
Feb. 14-15	2048-1032	.263	54	0.20	C
Feb. 15-16	2020-1002	.459	51	0.33	C
Mar. 9	1928-2344	.151	130	0.28	3
Mar. 10-11	2316-0330	.285	80	0.32	3
Mar. 25-26	2238-0250	.148	71	0.15	5
Mar. 29	1220-1658	.210	100	0.29	C
Mar. 29	1700-1910	.101	210	0.30	C
Sept. 24	0234-0812	.231	700	2.0	13
Oct. 25	0256-0518	.052	580	0.38	6
Oct. 26	0148-0626	.600	340	2.6	7
Nov. 8	1726-2028	.130	180	0.30	C
Nov. 9	1030-1850	.460	100	0.58	C
1983					
Jan. 18-19	1716-0134	.969	390	5.3	10
Jan. 24	0018-1336	.840	140	1.6	C
Feb. 28 - Mar. 1	1804-0832	1.22	79	1.4	C
Mar. 16	1654-2110	.429	110	0.66	C
Mar. 23-24	1958-0308	.620	69	0.60	C
Manganese, total recoverable (µg/L)					
1982					
Sept. 24	0234-0812	0.231	760	2.2	13
Oct. 25	0256-0518	.052	410	0.27	6
Oct. 26	0148-0626	.600	250	1.9	7
Nov. 8	1726-2028	.130	140	0.23	C
Nov. 9	1030-1850	.460	130	0.76	C
Manganese, total recoverable (µg/L)--Continued					
1983					
Jan. 18-19	1716-0134	0.969	300	4.1	10
Jan. 24	0018-1336	.840	210	2.5	C
Feb. 28 - Mar. 1	1804-0832	1.220	30	0.51	C
Mar. 16	1654-2110	.429	230	1.4	C
Mar. 23-24	1958-0308	.620	150	1.3	C
Mercury, total recoverable (µg/L)					
1981					
Nov. 17	0416-0816	0.234	0.1	<0.01	7
Dec. 29-30	1452-0444	.314	0.1	<0.01	C
1982					
Jan. 4	0754-2100	.772	0.1	<0.01	13
Feb. 4-15	2048-1032	.263	0.5	<0.01	C
Feb. 15-16	2020-1002	.459	0.3	<0.01	C
Mar. 9	1928-2344	.151	0.1	<0.01	3
Mar. 10-11	2316-0330	.285	0.1	<0.01	3
Mar. 25-26	2238-0250	.148	0.2	<0.01	5
Mar. 29	1220-1658	.210	0.1	<0.01	C
Mar. 29	1700-1910	.101	0.1	<0.01	C
Sept. 24	0234-0812	.231	0.4	<0.01	13
Oct. 25	0256-0518	.052	0.1	<0.01	6
Oct. 26	0148-0626	.600	0.1	<0.01	7
Nov. 8	1726-2028	.130	0.1	<0.01	C
Nov. 9	1030-1850	.460	0.1	<0.01	C
1983					
Jan. 18-19	1716-0134	.969	0.2	<0.01	10
Feb. 28- Mar. 1	1804-0832	1.22	0.1	<0.01	C
Mar. 16	1654-2110	.429	0.1	<0.01	C
Nickel, total recoverable (µg/L)					
1981					
Nov. 17	0416-0816	0.234	7	0.02	7
Dec. 29-30	1452-0444	.314	8	0.04	C
1982					
Jan. 4	0754-2100	.772	3	0.03	13
Feb. 14-15	2048-1032	.263	4	0.01	C
Feb. 15-16	2020-1002	.459	3	0.02	C
Mar. 9	1928-2344	.151	5	0.01	3
Mar. 10-11	2316-0330	.285	3	0.01	3
Mar. 25-26	2238-0250	.148	11	0.02	5
Mar. 29	1220-1658	.210	5	0.01	C
Mar. 29	1700-1910	.101	9	0.01	C
Sept. 24	0234-0812	.231	52	0.15	13
Oct. 25	0256-0518	.052	34	0.02	6
Oct. 26	0148-0626	.600	14	0.10	7
Nov. 8	1726-2028	.130	12	0.02	C
Nov. 9	1030-1850	.460	10	0.06	C

Table 21. Constituent storm-runoff loads: Commercial catchment—Continued

Date	Time	Total runoff volume	EMC	Event load	n
Nickel, total recoverable (µg/L)--Continued					
1983					
Jan. 18-19	1716-0134	0.969	26	0.35	10
Jan. 24	0018-1336	.840	9	0.11	C
Feb. 28 - Mar. 1	1804-0832	1.22	11	<0.01	C
Mar. 16	1654-2110	.429	22	0.13	C
Mar. 23-24	1958-0308	.620	11	0.10	C
Zinc, total recoverable (µg/L)					
1981					
Nov. 17	0416-0816	0.234	160	0.53	7
Dec. 29-30	1452-0444	.314	250	1.1	C
1982					
Jan. 4	0754-2100	.772	110	1.2	13
Feb. 14-15	2048-1032	.263	140	0.52	C
Feb. 15-16	2020-1002	.459	130	0.84	C
Mar. 9	1928-2344	.151	440	0.94	3
Mar. 10-11	2316-0330	.285	130	0.50	3
Mar. 25-26	2238-0250	.148	270	0.57	5
Mar. 29	1220-1658	.210	140	0.41	C
Mar. 29	1700-1910	.101	140	0.20	C
Nov. 8	1726-2028	.130	300	0.49	C
Nov. 9	1030-1850	.460	140	0.81	C
1983					
Jan. 24	0018-1336	.840	150	1.8	C
Feb. 28 - Mar. 1	1804-0832	1.22	70	1.2	C
Mar. 16	1654-2110	.429	190	1.1	C
Mar. 23-24	1958-0308	.620	120	1.0	C
Oxygen demand, chemical, 0.25 N dichromate (mg/L)					
1981					
Nov. 17	0416-0816	0.234	51.52	168	7
Dec. 29-30	1452-0444	.314	75	330	C
1982					
Jan. 4	0754-2100	.772	45	482	13
Feb. 14-15	2048-1032	.263	52	192	C
Feb. 15-16	2020-1002	.459	36	231	C
Mar. 9	1928-2344	.151	99	209	4
Mar. 10-11	2316-0330	.285	100	412	3
Mar. 25-26	2238-0250	.148	130	265	5
Mar. 29	1220-1658	.210	110	323	C
Mar. 29	1700-1910	.101	65	92	C
Nov. 9	1030-1850	.460	310	1,800	C
1983					
Jan. 24	0018-1336	.840	35	410	C
Feb. 1 - Mar. 1	1804-0832	1.22	25	427	C
Mar. 16	1654-2110	.429	51	307	C
Mar. 23-24	1958-0308	.620	34	296	C
Solids, sum of constituents, dissolved (mg/L)					
1981					
Nov. 17	0416-0816	0.234	23	75	7
Dec. 29-30	1452-0444	.314	27	119	C
1982					
Jan. 4	0754-2100	.772	18	198	13
Jan. 21	1348-1718	.206	18	52	e10
Feb. 14-15	2048-1032	.263	22	81	C
Feb. 15-16	2020-1002	.459	21	135	C
Mar. 9	1928-2344	.151	51	108	3
Mar. 10-11	2316-0330	.285	28	113	2
Mar. 11	1030-2040	.201	22	61	e17
Mar. 14	0342-1630	.959	19	249	e35
Mar. 16	0600-1338	.439	21	128	e21
Mar. 16-17	2002-0222	.320	19	86	e13
Mar. 18	0414-0956	.211	22	66	e9
Mar. 18	1330-1600	.151	28	59	e7
Mar. 25-26	2238-0250	.148	24	49	4
Mar. 29	1220-1658	.210	11	32	C
Mar. 29	1700-1910	.101	10	14	C
Apr. 10	0516-0934	.174	27	65	e9
Apr. 10	1124-1434	.159	21	47	e6
Apr. 11	1914-0020	.231	18	58	e9
Sept. 24	0234-0812	.231	81	235	13
Oct. 25	0256-0518	.052	73	48	6
Oct. 26	0148-0626	.600	26	194	7
Nov. 8	1726-2028	.130	56	92	C
Nov. 9	1030-1850	.460	28	162	C
1983					
Jan. 18-19	1716-0134	.969	20	266	10
Jan. 24	0018-1336	.840	20	234	C
Feb. 28 - Mar. 1	1804-0832	1.22	14	240	C
Mar. 16	1654-2110	.429	57	343	C
Mar. 23-24	1958-0308	.620	31	270	C
Sediment, suspended (mg/L)					
1981					
Nov. 17	0416-0816	0.234	139	454	7
Dec. 29-30	1452-0444	.314	60	264	C
1982					
Jan. 4	0754-2100	.772	31	332	13
Feb. 14-15	2048-1032	.263	12	44	C
Feb. 15-16	2020-1002	.459	17	110	C
Mar. 9	1928-2344	.151	35	75	3
Mar. 10-11	2316-0330	.285	29	117	3
Mar. 25-26	2238-0250	.148	35	72	5
Mar. 29	1220-1658	.210	47	138	C
Mar. 29	1700-1910	.101	104	147	C

Table 21. Constituent storm-runoff loads: Commercial catchment—Continued

Date	Time	Total runoff volume	EMC	Event load	n
Sediment, suspended (mg/L)--Continued					
1982					
Sept. 24	0234-0812	0.231	1,260	3,650	13
Oct. 25	0256-0518	.052	422	279	6
Oct. 26	0148-0626	.600	586	4,430	7
Nov. 8	1726-2028	.130	175	287	C
Nov. 9	1030-1850	.460	133	773	C
1983					
Jan. 18-19	1716-0134	.969	1,110	15,000	10
Jan. 24	0018-1336	.840	323	3,780	C
Feb. 28 - Mar. 1	1804-0832	1.22	404	6,910	C
Mar. 16	1654-2110	.429	291	1,750	C
Mar. 23-24	1958-0308	.620	167	1,450	C
Carbon, organic, dissolved (mg/L)					
1981					
Nov. 17	0416-0816	0.234	12	38	7
Dec. 29-30	1452-0444	.314	44	193	C
1982					
Jan. 4	0754-2100	.772	54	589	11
Feb. 14-15	2048-1032	.263	26	96	C
Feb. 15-16	2020-1002	.459	39	251	C
Mar. 9	1928-2344	.151	31	65	4
Mar. 10-11	2316-0330	.285	170	695	3
Mar. 25-26	2238-0250	.148	79	164	5
Mar. 29	1220-1658	.210	260	764	C
Mar. 29	1700-1910	.101	49	69	C
Nov. 8	1726-2028	.130	22	36	C
Nov. 9	1030-1850	.460	47	272	C
Carbon, organic, dissolved (mg/L)--Continued					
1983					
Jan. 24	0018-1336	0.840	14	164	C
Feb. 28 - Mar. 1	1804-0832	1.22	12	205	C
Mar. 16	1654-2110	.429	14	84	C
Mar. 23-24	1958-0308	.620	78	679	C
Carbon, organic, suspended (mg/L)					
1981					
Nov. 17	0416-0816	0.234	3.7	12	7
Dec. 29-30	1452-0444	.314	2.1	9.2	C
1982					
Jan. 4	0754-2100	.772	1.4	15	11
Feb. 14-15	2048-1032	.263	1.3	4.7	C
Feb. 15-16	2020-1002	.459	2.2	14	C
Mar. 9	1928-2344	.151	1.9	4.1	4
Mar. 10-11	2316-0330	.285	1.8	7.1	3
Mar. 25-26	2238-0250	.148	1.9	3.9	5
Mar. 29	1220-1658	.210	2.1	6.2	C
Mar. 29	1700-1910	.101	3.2	4.5	C
Nov. 8	1726-2028	.130	5.2	8.5	C
Nov. 9	1030-1850	.460	3.2	19	C
Feb. 28- Mar. 1	1804-0832	1.22	2.9	50	C
Mar. 23-24	1958-0308	.620	3.3	29	C

Table 22. Significant variables affecting constituent event mean concentrations

[RUNOFF, runoff volume; DRYHRS, number of dry hours since last storm; SFIRST, number of days since first storm of rain season. ., none of the three variables were significant]

Constituent	Catchment			
	Industrial	Single-dwelling residential	Multiple-dwelling residential	Commercial
Nutrients				
Nitrogen, ammonia plus organic, dissolved---------	RUNOFF, SFIRST	RUNOFF	DRYHRS, RUNOFF	DRYHRS, SFIRST
Nitrogen, nitrite plus nitrate, dissolved---------	DRYHRS	RUNOFF	DRYHRS, RUNOFF, SFIRST	DRYHRS, RUNOFF
Phosphorus, dissolved--------	RUNOFF	RUNOFF, DRYHRS, SFIRST	DRYHRS, RUNOFF	.
Oxygen demand				
Oxygen demand, chemical------	RUNOFF, SFIRST	DRYHRS	DRYHRS, RUNOFF	.
Organics				
Carbon, organic, dissolved---	.	.	.	.
Carbon, organic, suspended---	SFIRST	DRYHRS,	. SFIRST	.
Metals				
Arsenic, total---------------	.	.	.	.
Chromium, total recoverable--	.	.	DRYHRS, RUNOFF, SFIRST	.
Copper, total recoverable----	.	SFIRST	.	DRYHRS
Iron, total recoverable------	.	.	SFIRST	.
Lead, total recoverable------	.	SFIRST	SFIRST	.
Mercury, total recoverable---	DRYHRS	.	SFIRST	.
Nickel, total recoverable----	.	.	.	.
Zinc, total recoverable------	.	SFIRST	.	DRYHRS
Physical properties				
Solids, sum of constituents, dissolved------------------	.	.	DRYHRS, RUNOFF	DRYHRS
Sediment, suspended----------	.	SFIRST	SFIRST	RUNOFF

Table 23. Results of linear regression analysis using runoff event mean concentration data

[Form of equation: *a*, regression constant; *b*,*c*,*d*, regression coefficient; x_1, x_2, x_3, independent variable]

Dependent variable	Form of equation: $y = a+bx_1+cx_2+dx_3$							Adjusted percentage of variation explained (R^2)	Root mean square error	Number of data observations
	a	*b*	x_1	*c*	x_2	*d*	x_3			
Industrial catchment										
Nitrogen, ammonia plus organic, dissolved	24.0	-48.3	RUNOFF	-0.062	SFIRST	.	.	59	3.88	12
Nitrogen, nitrite plus nitrate, dissolved	0.4	-0.00258	DRYHRS	.	.	.	.	32	0.241	12
Phosphorus, dissolved	6.31	-15.7	RUNOFF	.	.	.	.	34	1.71	12
Oxygen demand, chemical	943	-1290	RUNOFF	-3.55	SFIRST	.	.	77	93.8	10
Carbon, organic, suspended	37.1	-0.110	SFIRST	.	.	.	.	26	7.95	11
Mercury, total recoverable	0.122	0.0000962	DRYHRS	.	.	.	.	27	0.040	12
Single-dwelling residential catchment										
Nitrogen, ammonia plus organic, dissolved	2.96	-7.98	RUNOFF	.	.	.	.	36	0.836	17
Nitrogen, nitrite plus nitrate, dissolved	0.619	-1.78	RUNOFF	.	.	.	.	39	0.177	17
Phosphorus, dissolved	0.307	0.000526	RUNOFF	-0.532	DRYHRS	-0.000619	SFIRST	69	0.044	17
Oxygen demand, chemical	29.3	0.615	DRYHRS	.	.	.	.	68	19.6	9
Carbon, organic, suspended	9.76	-0.016	DRYHRS	-0.040	SFIRST	.	.	69	1.44	8
Copper, total recoverable	25.2	-0.098	SFIRST	.	.	.	.	86	2.11	7
Lead, total recoverable	357	-1.77	SFIRST	.	.	.	.	88	37.5	9
Zinc, total recoverable	170	-0.585	SFIRST	.	.	.	.	63	23.3	7
Sediment, suspended	321	-1.80	SFIRST	.	.	.	.	71	66.7	10
Multiple-dwelling residential catchment										
Nitrogen, ammonia plus organic, dissolved	1.41	-1.44	RUNOFF	.	DRYHRS	.	.	49	0.515	31
Nitrogen, nitrite plus nitrate, dissolved	0.213	-0.308	RUNOFF	0.000573	DRYHRS	0.00119	SFIRST	33	0.140	30
Phosphorus, dissolved	0.190	-0.127	RUNOFF	0.000443	DRYHRS	.	.	51	0.057	32
Oxygen demand, chemical	80.5	-51.3	RUNOFF	0.100	DRYHRS	.	.	57	16.6	16
Solids, sum of constituents, dissolved	29.4	-14.2	RUNOFF	0.0235	DRYHRS			39	5.21	31
Chromium, total recoverable	29.8	-9.76	RUNOFF	-0.017	DRYHRS	-0.094	SFIRST	64	3.91	18
Iron, total recoverable	11300	-46.5	SFIRST	.	.	.	.	34	2750	17
Lead, total recoverable	247	-0.767	SFIRST	.	.	.	.	18	69.5	18
Mercury, total recoverable	0.307	-0.000991	SFIRST	.	.	.	.	29	0.071	15
Sediment, suspended	788	-4.00	SFIRST	.	.	.	.	52	182	12
Commercial catchment										
Nitrogen, ammonia plus organic, dissolved	2.60	0.00570	DRYHRS	-0.011	SFIRST	.	.	28	0.939	28
Nitrogen, nitrite plus nitrate, dissolved	0.4	-0.00213	DRYHRS	-0.267	RUNOFF	.	.	47	0.183	28
Solids, sum of constituents, dissolved	20.2	0.104	DRYHRS	.	.	.	.	34	9.45	28
Copper, total recoverable	11.4	0.046	DRYHRS	.	.	.	.	43	3.70	16
Zinc, total recoverable	124	1.04	DRYHRS	.	.	.	.	64	56.4	16
Sediment, suspended	22.3	305	RUNOFF	.	.	.	.	29	137	17

Table 24. Statistical summary of runoff event mean concentration data for all monitored catchments

[Computation maximum and minimum are the maximum and minimum event mean concentrations (EMC) of data set used to compute mean after excluding early rain season high event mean concentration. Study maximum equals maximum event mean concentration for study period. ., no data available]

Catchment	Mean	Standard error	Number of EMC values	Computation		Study maximum
				Maximum	Minimum	
			Nitrogen, ammonia plus organic, dissolved (mg/L as N)			
Industrial	13	1.8	12	22	3.6	28
Single-dwelling residential	2.0	0.25	17	4.8	0.68	12
Multiple-dwelling residential	1.4	0.13	31	3.2	0.20	7.4
Commercial	1.6	0.21	28	3.4	0.70	9.0
			Nitrogen, nitrite plus nitrate, dissolved (mg/L as N)			
Industrial	0.63	0.08	12	1.1	0.28	3.9
Single-dwelling residential	0.40	0.06	17	0.97	0.14	3.2
Multiple-dwelling residential	0.33	0.03	30	0.83	0.13	2.2
Commercial	0.41	0.05	28	1.1	0.12	3.6
			Phosphorus, dissolved (mg/L as P)			
Industrial	4.8	0.48	15	7.8	2.0	7.8
Single-dwelling residential	0.20	0.02	17	0.38	0.09	0.99
Multiple-dwelling residential	0.20	0.01	32	0.43	0.06	0.82
Commercial	0.11	0.01	28	0.36	0.02	0.65
			Aluminum, total recoverable (μg/L)			
Industrial	6,500	330	3	7,100	6,000	7,100
Single-dwelling residential	1,700	540	5	3,400	560	3,400
Multiple-dwelling residential	2,900	450	5	4,400	1,600	4,400
Commercial	.	.	0	.	.	.
			Arsenic, total (μg/L)			
Industrial	18	2	17	30	8	30
Single-dwelling residential	1	0	8	2	1	4
Multiple-dwelling residential	2	0	13	2	1	8
Commercial	2	0	15	7	1	17
			Chromium, total recoverable (μg/L)			
Industrial	21	4	14	51	8	51
Single-dwelling residential	7	2	8	13	1	13
Multiple-dwelling residential	15	2	18	28	6	28
Commercial	11	1	16	23	3	23

Table 24. Statistical summary of runoff event mean concentration data for all monitored catchments—Continued

Catchment	Mean	Standard error	Number of EMC values	Computation		Study maximum
				Maximum	Minimum	
Copper, total recoverable (µg/L)						
Industrial	68	6	14	110	39	110
Single-dwelling residential	12	2	7	24	7	39
Multiple-dwelling residential	18	2	16	33	9	100
Commercial	14	1	16	23	6	23
Iron, total recoverable (µg/L)						
Industrial	11,000	1,600	17	34,000	4,000	34,000
Single-dwelling residential	2,000	560	9	5,000	450	10,000
Multiple-dwelling residential	5,700	820	17	15,000	2,500	33,000
Commercial[1]	1,100	180	10	2,500	430	2,500
Lead, total recoverable (µg/L)						
Industrial	87	12	17	210	27	210
Single-dwelling residential	140	36	9	360	61	740
Multiple-dwelling residential	160	18	18	350	63	670
Commercial[1]	100	16	10	210	51	210
Manganese, total recoverable (µg/L)						
Industrial	350	50	6	570	230	570
Single-dwelling residential	60	20	6	120	30	300
Multiple-dwelling residential	90	10	6	120	60	840
Commercial	.	.	0	.	.	.
Mercury, total recoverable (µg/L)						
Industrial	0.1	0.0	12	0.2	0.1	1.4
Single-dwelling residential	0.2	0.1	6	0.6	0.1	2.4
Multiple-dwelling residential	0.2	0.0	15	0.4	0.1	1.3
Commercial	0.1	0.0	14	0.2	0.1	0.5
Nickel, total recoverable (µg/L)						
Industrial	25	3	17	52	6	52
Single-dwelling residential	11	2	9	19	3	56
Multiple-dwelling residential	16	2	17	31	5	120
Commercial[1]	6	1	10	11	3	11
Zinc, total recoverable (µg/L)						
Industrial	520	40	14	840	320	840
Single-dwelling residential	90	10	7	160	60	190
Multiple-dwelling residential	150	10	16	290	70	1,100
Commercial	180	20	16	440	70	440

Table 24. Statistical summary of runoff event mean concentration data for all monitored catchments—Continued

Catchment	Mean	Standard error	Number of EMC values	Computation		Study maximum
				Maximum	Minimum	
			Oxygen demand, chemical, 0.25 N dichromate (mg/L)			
Industrial	460	45	9	630	290	970
Single-dwelling residential	65	12	9	130	27	170
Multiple-dwelling residential	78	6	16	110	38	470
Commercial	81	18	15	310	25	310
			Solids, sum of constituents, dissolved (mg/L)			
Industrial	121	13	13	201	22	1,006
Single-dwelling residential	27	2.4	16	44	15	93
Multiple-dwelling residential	28	1.2	31	40	16	83
Commercial	25	2.2	28	57	10	81
			Sediment, suspended (mg/L)			
Industrial	578	77	9	954	231	954
Single-dwelling residential	105	37	10	392	22	538
Multiple-dwelling residential	313	76	12	924	91	1,910
Commercial[1]	51	13	10	139	12	139
			Carbon, organic, dissolved (mg/L)			
Industrial	170	57	12	750	20	750
Single-dwelling residential	68	17	9	150	4.4	150
Multiple-dwelling residential	54	17	16	270	6.6	270
Commercial	60	17	16	260	12	260
			Carbon, organic, suspended (mg/L)			
Industrial	28	2.8	11	40	10	40
Single-dwelling residential	3.5	0.92	8	9.3	1.4	9.3
Multiple-dwelling residential	3.1	0.22	15	5.1	1.9	5.1
Commercial	2.6	0.28	14	5.2	1.3	5.2

[1] Only first rain season event mean concentrations used.

Table 25. Estimated average annual constituent unit loads for each land-use type

	Catchment			
	Industrial	Single-dwelling residential	Multiple-dwelling residential	Commercial
Mean rainfall-runoff coefficient*	0.18	0.21	0.39	0.93
Mean annual catchment runoff, in inches**	1.84	2.15	3.99	9.52
Constituent	Mean annual constituent unit load (pounds per acre)			
Nitrogen, organic plus ammonia, dissolved	5.6	.95	1.2	3.4
Nitrogen, nitrite plus nitrate, dissolved	0.26	0.19	0.30	0.88
Phosphorus, dissolved	2.0	0.10	0.18	0.24
Oxygen demand, chemical	190	32	70	180
Carbon, organic, dissolved	77	33	49	130
Carbon, organic, suspended	11	1.7	2.8	5.6
Aluminum, total recoverable	2.7	0.81	2.7	.
Arsenic, total	0.0074	0.0005	0.0014	0.0040
Chromium, total recoverable	0.0088	0.0036	0.014	0.024
Copper, total recoverable	0.028	0.0057	0.016	0.030
Iron, total recoverable	4.5	1.0	5.2	2.4
Lead, total recoverable	0.036	0.068	0.14	0.22
Manganese, total recoverable	0.15	0.029	0.084	.
Mercury, total recoverable	0.0001	0.0001	0.0002	0.0002
Nickel, total recoverable	0.010	0.0054	0.014	0.013
Zinc, total recoverable	0.21	0.044	0.14	0.39
Solids, sum of constituents, dissolved	50	13	25	54
Sediment, suspended	240	51	283	110

*Taken from table 5.

**Based on average annual rainfall of 10.24 inches.

Table 26. Statistical summary of atmospheric dry-deposition quality data: Industrial site

[Statistical calculations include analytical detection limit concentration for those analyses that are reported to be less than detection limit. Mass concentrations determined by dividing bucket-washed sample constituent concentration by total solids concentration and muliplying by 10^6. <, actual value is less than value shown. ., not calculated]

Property or constituent	Number of samples	Mean	Standard deviation	Maximum	Minimum
INORGANICS					
Major ions (mg/kg)					
Calcium, dissolved	10	12,400	9,040	31,100	2,760
Magnesium, dissolved	10	5,950	5,760	2,100	780
Sodium, dissolved	10	9,070	6,950	21,000	1,380
Potassium, dissolved	10	18,500	20,700	74,200	2,760
Sulfate, dissolved	10	63,800	58,000	178,000	<922
Chloride, dissolved	10	9,360	7,340	25,800	2,300
Silica, dissolved	5	3,000	2,540	7,320	1,050
Nutrients (mg/kg)					
Nitrogen, nitrite plus nitrate, dissolved (as N)	10	9,330	12,400	42,200	1,200
Nitrogen, ammonia, total (as N)	10	12,000	13,900	46,800	1,050
Nitrogen, ammonia plus organic, total (as N)	10	62,200	43,200	136,000	13,400
Nitrogen, organic, total (as N)	9	52,100	40,400	129,000	12,400
Phosphorus, total (as P)	10	5,160	2,990	10,600	1,290
Phosphorus, orthophosphate, total (as P)	10	4,490	7,620	25,800	553
Metals (μg/kg)					
Aluminum, total recoverable	5	18,400,000	12,400,000	33,300,000	8,290,000
Aluminum, dissolved	2	451,000	305,000	667,000	235,000
Arsenic, total	5	14,400	8,490	23,500	4,610
Chromium, total recoverable	5	155,500	97,100	289,000	27,600
Copper, total recoverable	5	415,000	205,000	689,000	115,000
Copper, dissolved	2	183,000	150,000	289,000	76,500
Iron, total recoverable	5	25,000,000	15,900,000	42,400,000	11,100,000
Iron, dissolved	2	330,000	67,900	378,000	282,000
Lead, total recoverable	10	627,000	434,000	1,610,000	140,000
Lead, dissolved	7	36,300	42,200	97,600	<3,380
Manganese, total recoverable	5	754,000	512,000	1,330,000	276,000
Manganese, dissolved	2	282,000	9,190	289,000	276,000
Mercury, total recoverable	5	2,140	1,530	4,440	741
Nickel, total recoverable	5	134,000	115,000	329,000	27,600
Nickel, dissolved	2	25,800	5,090	29,400	<22,200
Zinc, total recoverable	5	1,630,000	775,000	2,440,000	369,000
Zinc, dissolved	2	534,000	189,000	667,000	400,000
PHYSICAL PROPERTIES					
Solids, residue at 105°C, total, (mg/L)	10	211	243	856	41
Solids, sum of constituents, dissolved (mg/kg)	4	226,000	203,000	452,000	44,400
ORGANICS					
Carbon, organic, dissolved (mg/kg as C)	10	118,000	123,000	390,000	10,100
Pesticides (μg/kg)					
Chlordane, total recoverable	1	270	.	270	270
DDE, total recoverable	1	13	.	13	13
Diazinon, total recoverable	1	120	.	120	120
Lindane, total recoverable	1	13	.	13	13
Malathion, total recoverable	1	200	.	200	200

Table 26. Statistical summary of atmospheric dry-deposition quality data: Industrial site—Continued

Other pesticides analyzed but not detected (one sample)					
Pesticide (total recoverable)	*Detection limit (μg/L)	Pesticide (total recoverable)	*Detection limit (μg/L)	Pesticide (total recoverable)	*Detection limit (μg/L)
Aldrin	0.01	Gross polychlorinated napthalenes	0.1	Parathion	0.01
DDD	0.01	Heptachlor	0.01	Perthane	0.1
DDT	0.01	Heptachlor epoxide	0.01	Silvex	0.01
Dieldrin	0.01	Methoxychlor	0.01	Toxaphene	1
Endosulfan	0.01	Methyl parathion	0.01	Trithion	0.01
Endrin	0.01	Methyl trithion	0.01	2,4-D	0.01
Ethion	0.01	Mirex	0.01	2,4-DP	0.01
Gross polychlorinated biphenyls	0.1			2,4,5-T	0.01

*Detection limit not converted to mass units.

Table 27. Statistical summary of atmospheric dry-deposition quality data: Single-dwelling residential site

[Statistical calculations include analytical detection level concentration for those analyses that are reported to be less than detection level. Mass concentrations determined by dividing bucket-washed sample constituent concentration by total solids concentrations and mutiplying by 10^6. <, actual value is less than value shown. ., not calculated]

Property or constituent	Number of samples	Mean	Standard deviation	Maximum	Minimum
INORGANICS					
Major ions (mg/kg)					
Calcium, dissolved	9	24,400	36,900	121,000	3,770
Magnesium, dissolved	9	5,000	4,640	13,800	638
Sodium, dissolved	9	16,000	15,600	55,200	<4,260
Potassium, dissolved	9	8,030	7,080	24,100	1,890
Sulfate dissolved	9	79,200	90,800	<250,000	4,260
Chloride, dissolved	9	15,000	17,800	58,600	498
Silica, dissolved	4	12,600	9,750	24,100	3,430
Nutrients (mg/kg)					
Nitrogen, nitrite plus nitrate, dissolved (as N)	9	41,300	95,700	295,000	1,890
Nitrogen, ammonia, total (as N)	9	13,700	26,500	82,800	<114
Nitrogen, ammonia plus organic, total (as N)	9	35,500	29,300	93,100	5,690
Nitrogen, organic, total (as N)	7	24,400	20,600	70,000	10,300
Phosphorus, total (as P)	9	2,480	1,900	6,900	588
Phosphorus, orthophosphate, total (as P)	9	1,500	1,700	5,860	304
Metals (μg/kg)					
Aluminum, total recoverable	5	17,400,000	13,000,000	40,500,000	9,950,000
Aluminum, dissolved	2	568,000	611,000	1,000,000	136,000
Arsenic, total	5	22,800	16,600	<50,000	4,500
Chromium, total recoverable	5	125,000	78,500	250 000	56,600
Copper, total recoverable	5	649,000	749,000	1,950,000	90,500
Copper, dissolved	2	518,000	682,000	1,000,000	36,200

Table 27. Statistical summary of atmospheric dry-deposition quality data: Single-dwelling residential site—Continued

Property or constituent	Number of samples	Mean	Standard deviation	Maximum	Minimum
INORGANICS--Continued					
Metals (µg/kg)--Continued					
Iron, total recoverable	5	23,500,000	14,900,000	50,000,000	15,200,000
Iron, dissolved	2	298,000	286,000	500,000	95,000
Lead, total recoverable	9	2,390,000	2,510,000	8,280,000	304,000
Lead, dissolved	6	102,000	114,000	310,000	3,800
Manganese, total recoverable	5	610,000	498,000	1,500,000	36,2000
Manganese, dissolved	2	245,000	219,000	400,000	90,500
Mercury, total recoverable	5	4,180	3,530	10,000	905
Nickel, total recoverable	5	136,000	138,000	350,000	21,300
Nickel, dissolved	2	27,300	32,200	50,000	4,520
Zinc, total recoverable	5	2,140,000	1,360,000	4,000,000	543,000
Zinc, dissolved	2	1,200,000	1,490,000	2,250,000	140,000
PHYSICAL PROPERTIES					
Solids, residue at 105°C total, (mg/L)	9	135	164	527	20
Solids, sum of constituents, dissolved (mg/kg)	4	318,000	366,000	862,000	91,100
ORGANICS					
Carbon, organic, dissolved (mg/kg as C)	7	118,000	81,800	266,000	30,400
Pesticides (µg/kg)					
Chlordane, total recoverable	1	610	.	610	610
DDE, total recoverable	1	30	.	30	30
Diazinon, total recoverable	1	180	.	180	180
Lindane, total recoverable	1	30	.	30	30
Malathion, total recoverable	1	850	.	850	850
Methoxychlor, total recoverable	1	30	.	30	30

Other pesticides analyzed but not detected (one sample)

Pesticide (total recoverable)	*Detection limit (µg/L)	Pesticide (total recoverable)	*Detection limit (µg/L)	Pesticide (total recoverable)	*Detection limit (µg/L)
Aldrin	0.01	Gross polychlorinated napthalenes	0.1	Perthane	0.1
DDD	0.01	Heptachlor	0.01	Silvex	0.01
DDT	0.01	Heptachlor epoxide	0.01	Toxaphene	1
Dieldrin	0.01	Methyl parathion	0.01	Trithion	0.01
Endosulfan	0.01	Methyl trithion	0.01	2,4-D	0.01
Endrin	0.01	Mirex	0.01	2,4-DP	0.01
Ethion	0.01	Parathion	0.01	2,4,5-T	0.01
Gross polychlorinated biphenyls	0.1				

*Detection limit not converted to mass units.

Table 28. Statistical summary of street-surface particulate quality samples: Industrial catchment

[Statistical calculations include analytical detection limit concentration for those analyses that are reported to be less than detection limit. The analytical detection limit increased with increased quantities of constituents such as oils and greases that interfere with analytical instrumentation. <, actual value is less than the value shown]

Constituent, in bottom materials	Number of samples	Mean	Median	Standard error of mean	Standard deviation	Maximum	Minimum
INORGANICS							
Major ions (mg/kg)							
Calcium, total recoverable	3	40	40	0	10	40	30
Magnesium, total recoverable	3	30	40	10	10	40	20
Sodium, total recoverable	3	10	<10	0	0	<10	<10
Potassium, total recoverable	3	350	310	40	60	420	310
Nutrients (mg/kg)							
Nitrogen, nitrite, total (as N)	3	2	<2	0	0	<2	<2
Nitrogen, nitrite plus, nitrate, total (as N)	5	4.4	4.0	1.2	2.6	7.4	<2.0
Nitrogen, ammonia, total (as N)	5	38	38	12	28	80	6
Nitrogen, ammonia plus organic, total (as N)	5	530	430	130	280	1,000	300
Nitrogen, total (as N)	3	453	437	66	114	574	347
Phosphorus, total (as P)	5	200	210	20	50	250	120
Metals (µg/g)							
Aluminum, total recoverable	2	800	805	20	40	830	780
Arsenic, total	5	3	3	0	1	4	2
Cadmium, total recoverable	3	4	1	3	5	<10	<1
Chromium, total recoverable	3	20	10	10	10	30	10
Copper, total recoverable	5	38	40	5	11	54	27
Iron, total recoverable	5	2,600	2,300	330	740	3,700	2,000
Lead, total recoverable	5	160	150	40	80	300	100
Manganese, total recoverable	2	40	40	6	4	46	34
Mercury, total recoverable	5	0.02	0.02	0.00	0.01	0.03	0.01
Nickel, total recoverable	5	38	20	16	35	<100	20
Zinc, total recoverable	5	76	70	12	27	120	49
OXYGEN DEMAND (mg/kg)							
Oxygen demand, chemical, total	5	41,000	4,000	6,400	14,000	65,000	30,000
PHYSICAL PROPERTIES (mg/kg)							
Residue, loss on ignition	5	26,300	8,400	2,150	4,800	31,100	19,900
ORGANICS							
Carbon, inorganic plus organic, total (g/kg as C)	5	13	11	1.0	3	17	10
Carbon, inorganic, total (g/kg as C)	5	0.1	<0.1	0.0	0.0	0.2	<0.1
Pesticides (total recoverable, µg/kg)							
Aldrin	5	1.5	<1.0	0.6	1.4	<4.0	<0.5
Chlordane	5	140	110	33	75	260	69
DDD	5	1.3	<0.5	0.7	1.5	<4.0	<0.5
DDE	5	12	12	1.1	2.5	15	8.1
DDT	5	21	21	4.3	9.6	33	7.4
Diazinon	5	4.7	<1.0	3.8	8.6	20	<0.1
Dieldrin	5	1.2	1.2	0.4	0.8	2.3	0.2
Endosulfan	5	1.3	<0.5	0.7	1.5	<4.0	<0.5
Endrin	5	0.7	<0.5	0.1	0.2	<1.0	<0.5
Ethion	5	0.8	<1.0	0.2	0.4	<1.0	<0.1
Heptachlor epoxide	5	1.4	<0.5	0.6	1.2	2.8	<0.5
Heptachlor	5	1.1	0.5	0.7	1.6	<4.0	0.2
Lindane	5	2.6	2.1	0.5	1.1	4.6	2.0

Table 28. Statistical summary of street-surface particulate quality samples: Industrial catchment—Continued

Constituent, in bottom materials	Number of samples	Mean	Median	Standard error of mean	Standard deviation	Maximum	Minimum
ORGANICS--Continued							
Pesticides (total recoverable, µg/kg)--Continued							
Malathion	5	1.0	<1.0	0.3	0.7	2.1	<0.1
Methoxychlor	5	2.9	<2.5	1.3	3.0	<8.0	<0.5
Methyl parathion	5	0.8	<1.0	0.2	0.4	<1.0	<0.1
Methyl trithion	5	0.8	<1.0	0.2	0.4	<1.0	<0.1
Mirex	5	1.5	<1.0	0.6	1.4	<4.0	<0.5
Parathion	5	3.8	<1.0	3.1	6.8	16	<0.1
PCB	5	30	33	3	6	37	23
PCN	2	10	<10	0.0	0.0	<10	<10
Perthane	5	13	<5	7	15	<40	<5
Toxaphene	5	130	<50	70	150	<400	<50
Trithion	5	0.8	<1.0	0.2	0.4	<1.0	<0.1
2,4-D	2	0.5	<0.5	0.0	0.0	<0.5	<0.5

Table 29. Statistical summary of street-surface particulate quality samples: Single-dwelling residential catchment

[Statistical calculations include analytical detection limit concentration for those analyses that are reported to be less than detection limit. The analytical detection limit increased with increased quantities of constituents such as oils and greases that interfere with analytical instrumentation. <, actual value is less than value shown]

Constituent, in bottom materials	Number of samples	Mean	Median	Standard error of mean	Standard deviation	Maximum	Minimum
INORGANICS							
Major ions (mg/kg)							
Calcium, total recoverable	3	70	60	20	40	110	30
Magnesium, total recoverable	3	20	20	0	0	20	20
Sodium, total recoverable	3	10	<10	0	0	<10	<10
Potassium, total recoverable	3	760	800	40	60	800	690
Nutrients (mg/kg)							
Nitrogen, nitrite, total (as N)	3	2	<2	0	0	>2	<2
Nitrogen, nitrite plus nitrate, total (as N)	5	5.5	4.1	1.7	3.9	12	<2.0
Nitrogen, ammonia, total (as N)	5	35	31	8	18	64	19
Nitrogen, ammonia plus organic, total (as N)	5	900	1,000	130	300	1,200	500
Nitrogen, total (as N)	4	878	897	168	336	1,210	507
Phosphorus, total (as P)	5	450	260	190	420	1,200	220
Metals (µg/g)							
Aluminum, total recoverable	2	1,200	1,250	150	210	1,400	1,100
Arsenic, total	5	2	2	0	1	3	2
Cadmium, total recoverable	3	4	<1	3	5	<10	<1
Chromium, total recoverable	3	4	4	0	0	4	4
Copper, total recoverable	5	14	12	2	4	18	<10
Iron, total recoverable	5	3,100	3,200	250	570	3,600	2,100
Lead, total recoverable	5	560	510	60	130	790	500
Manganese, total recoverable	2	54	54	11	16	65	43
Mercury, total recoverable	5	0.03	0.03	0.01	0.01	0.05	0.01
Nickel, total recoverable	5	28	10	18	40	<100	<10
Zinc, total recoverable	5	220	85	140	320	800	59

Table 29. Statistical summary of street-surface particulate quality samples: Single-dwelling residential catchment—Continued

Constituent, in bottom materials	Number of samples	Mean	Median	Standard error of mean	Standard deviation	Maximum	Minimum
OXYGEN DEMAND (mg/kg)							
Oxygen demand, chemical, total-----	5	52,000	50,000	4,100	9,200	66,000	44,000
PHYSICAL PROPERTIES (mg/kg)							
Residue, loss on ignition----------	5	62,500	58,000	10,000	22,400	98,000	36,100
ORGANICS							
Carbon, inorganic plus organic, total (g/kg as C)----------------	5	21	20	1.0	3	25	18
Carbon, inorganic, total (g/kg as C)----------------	5	0.2	<1.0	0.1	0.3	0.7	<0.1
Pesticides (total recoverable, µg/kg)							
Aldrin-----------------------------	5	0.9	<1.0	0.1	0.2	<1.0	<0.5
Chlordane--------------------------	5	300	290	46	110	470	170
DDD--------------------------------	5	1.5	<1.0	0.6	1.4	<4.0	<0.5
DDE--------------------------------	5	6.5	6.0	1.3	2.8	11	3.3
DDT--------------------------------	5	17	15	4	8	31	11
Diazinon---------------------------	5	7.4	6.0	2.8	6.2	18	3.0
Dieldrin---------------------------	5	3.1	3.7	0.8	1.7	5.2	0.7
Endosulfan-------------------------	5	1.5	<1.0	0.6	1.4	<4.0	<0.5
Endrin-----------------------------	5	0.9	<1.0	0.1	0.2	<1.0	<0.5
Ethion-----------------------------	5	0.8	<1.0	0.2	0.4	<1.0	<0.1
Heptachlor epoxide-----------------	5	0.9	<1.0	0.1	0.3	1.2	<0.5
Heptachlor-------------------------	5	1.5	1.4	0.2	0.5	2.2	1.0
Lindane----------------------------	5	7.5	2.8	4.6	10	26	1.5
Malathion--------------------------	5	4.1	2.9	1.6	3.6	10	<1.0
Methoxychlor-----------------------	5	2.3	<1.0	1.4	3.2	<8.0	<0.5
Methyl parathion-------------------	5	0.8	<1.0	0.2	0.4	<1.0	<0.1
Methyl trithion--------------------	5	0.8	<1.0	0.2	0.4	<1.0	<0.1
Mirex------------------------------	5	0.9	<1.0	0.1	0.2	<1.0	<0.5
Parathion--------------------------	5	6.4	<1.0	5.6	13	29	<0.1
Gross polychlorinated biphenyls----	5	21	13	8	17	51	10
Gross polychlorinated naphthalenes--------------------	2	10	<10	0	0	<10	<10
Perthane---------------------------	5	15	<10	6	14	<40	<5
Toxaphene--------------------------	5	150	<100	60	140	<400	<50
Trithion---------------------------	5	0.8	<1.0	0.2	0.4	<1.0	<0.1
2,4-D------------------------------	2	0.5	<0.5	0.0	0.0	<0.5	<0.5

Table 30. Statistical summary of street-surface particulate quality samples: Multiple-dwelling residential catchment

[Statistical calculations include analytical detection limit concentration for those analyses that are reported to be less than detection limit. The analytical detection limit increased with increased quantities of constituents such as oils and greases that interfere with analytical instrumentation. <, actual value is less than value shown]

Constituent, in bottom materials	Number of samples	Mean	Median	Standard error of mean	Standard deviation	Maximum	Minimum
INORGANICS							
Major ions (mg/kg)							
Calcium, total recoverable---------	3	30	30	0	10	40	30
Magnesium, total recoverable-------	3	20	20	0	10	20	10
Potassium, total recoverable-------	3	530	500	60	100	640	460
Sodium, total recoverable----------	3	10	<10	0.0	0.0	<10	<10

Table 30. Statistical summary of street-surface particulate quality samples: Multiple-dwelling residential catchment—Continued

Constituent, in bottom materials	Number of samples	Mean	Median	Standard error of mean	Standard deviation	Maximum	Minimum
INORGANICS--Continued							
Nutrients (mg/kg)							
Nitrogen, nitrite, total (as N)----	3	2	<2	0.0	0.0	>2	<2
Nitrogen, nitrite plus nitrate, total (as N)---------------------	5	7.3	5.0	2.3	5.1	15	<2.0
Nitrogen, ammonia, total (as N)----	5	30	30	3.0	6.5	38	22
Nitrogen, ammonia plus organic, total (as N)---------------------	5	440	470	60	130	570	250
Nitrogen, total (as N)-------------	4	429	440	69	138	580	255
Phosphorus, total (as P)-----------	5	210	180	20	60	300	160
Metals (µg/g)							
Aluminum, total recoverable--------	2	1,200	1,200	490	690	1,700	720
Arsenic, total---------------------	5	2	2	0	1	2	1
Cadmium, total recoverable---------	3	4	1	3	5	10	1
Chromium, total recoverable--------	3	3	3	0	1	4	3
Copper, total recoverable----------	5	10	<10	2	5	17	5
Iron, total recoverable------------	5	2,400	2,400	330	740	3,000	1,200
Lead, total recoverable------------	5	330	400	50	110	430	200
Manganese, total recoverable-------	2	46	46	14	21	60	31
Mercury, total recoverable---------	5	0.03	0.03	0.00	0.01	0.04	0.02
Nickel, total recoverable----------	5	28	<10	18	40	<100	8
Zinc, total recoverable------------	5	72	49	20	45	150	40
OXYGEN DEMAND (mg/kg)							
Oxygen demand, chemical, total-----	5	36,000	37,000	3,900	8,700	49,000	25,000
PHYSICAL PROPERTIES (mg/kg)							
Residue, loss on ignition ---------	5	27,700	20,600	6,440	14,400	53,200	19,600
ORGANICS							
Carbon, inorganic plus organic, total (g/kg as C)----------------	5	12	11	1	1	14	11
Carbon, inorganic, total (g/kg as C)----------------	5	0.1	0.1	0.0	0.0	0.2	<0.1
Pesticides (total recoverable, µg/kg)							
Aldrin-----------------------------	5	0.7	<0.5	0.1	0.3	<1.0	<0.5
Chlordane--------------------------	5	110	110	17	39	160	57
DDD--------------------------------	5	0.6	<0.5	0.1	0.3	<1.0	<0.2
DDE--------------------------------	5	5.7	4.5	1.4	3.1	10	3.1
DDT--------------------------------	5	5.9	4.4	2.7	6.0	15	<0.5
Diazinon---------------------------	5	8.0	3.9	4.3	9.6	25	1.8
Dieldrin---------------------------	5	1.6	1.2	0.5	1.1	2.8	0.3
Endosulfan-------------------------	5	1.8	<0.5	1.2	2.8	6.7	<0.2
Endrin-----------------------------	5	0.5	<0.5	0.2	0.4	<1.0	<0.1
Ethion-----------------------------	5	0.5	<0.1	0.2	0.5	<1.0	<0.1
Heptachlor epoxide-----------------	5	0.7	<0.5	0.4	0.9	2.2	<0.1
Heptachlor-------------------------	5	1.2	1.2	0.2	0.5	1.9	<0.8
Lindane----------------------------	5	1.6	1.5	0.5	1.0	3.3	0.6
Malathion--------------------------	5	3.1	2.1	1.5	3.4	8.7	<0.1
Methoxychlor-----------------------	5	2.9	<2.5	1.3	3.0	<8.0	<0.5
Methyl parathion-------------------	5	0.5	<0.1	0.2	0.5	<1.0	<0.1
Methyl trithion--------------------	5	0.5	<0.1	0.2	0.5	<1.0	<0.1
Mirex------------------------------	5	0.7	<0.5	0.1	0.2	<1.0	<0.5
Parathion--------------------------	5	8.0	1.0	7.0	16	36	<0.1
Gross polychlorinated biphenyls----	5	38	38	3	8	49	30
Gross polychlorinated naphthalenes---------------------	2	5.0	<5	0	0	<5	<5

Table 30. Statistical summary of street-surface particulate quality samples: Multiple-dwelling residential catchment—Continued

Constituent, in bottom materials	Number of samples	Mean	Median	Standard error of mean	Standard deviation	Maximum	Minimum
ORGANICS--Continued							
Pesticides (total recoverable, µg/kg)--Continued							
Perthane	5	6	<5	1	3	<10	<2
Toxaphene	5	60	<50	10	30	<100	<20
Trithion	5	0.5	<0.1	0.2	0.5	<1.0	<0.1
2,4-D	2	0.5	<0.5	0.0	0.0	<0.5	<0.5

Table 31. Statistical summary of street-surface particulate quality samples: Commercial catchment

[Statistical calculations include analytical detection limit concentration for those analyses that are reported to be less than detection limit. The analytical detection limit increased with increased quantities of constituents such as oils and greases that interfere with analytical instrumentation. <, actual value is less than value shown. ., not calculated]

Constituent, in bottom materials	Number of samples	Mean	Median	Standard error of mean	Standard deviation	Maximum	Minimum
INORGANICS							
Major ions (mg/kg)							
Calcium, total recoverable	4	90	80	10	20	120	70
Magnesium, total recoverable	4	40	40	0	10	50	30
Sodium, total recoverable	4	<10	<10	0.0	0.0	<10	<10
Potassium, total recoverable	4	950	1,000	230	460	1,400	500
Nutrients (mg/kg)							
Nitrogen, nitrate, total (as N)	4	2	<2	0.0	0.0	>2	<2
Nitrogen, nitrite plus nitrate, total (as N)	6	16	13	5.4	13	42	6.6
Nitrogen, ammonia, total (as N)	6	48	39	11	28	100	24
Nitrogen, ammonia plus organic, total (as N)	6	1,190	1,250	190	470	1,900	630
Nitrogen, total (as N)	6	1,200	1,270	193	472	1,910	643
Phosphorus, total (as P)	6	330	340	40	90	450	180
Metals (µg/g)							
Aluminum, total recoverable	2	1,600	.	350	500	1,900	1,200
Arsenic, total	6	4	4	1	2	7	1
Cadmium, total recoverable	4	4	2	2	4	<10	1
Chromium, total recoverable	4	20	20	0.0	0.0	20	20
Copper, total recoverable	6	34	34	5	13	50	12
Iron, total recoverable	6	4,800	5,000	680	1,700	7,000	2,500
Lead, total recoverable	6	770	810	110	270	1,000	280
Manganese, total recoverable	2	85	86	24	35	110	61
Mercury, total recoverable	6	0.08	0.07	0.01	0.03	0.13	0.05
Nickel, total recoverable	6	36	26	13	32	<100	10
Zinc, total recoverable	6	410	740	180	440	1,300	130
OXYGEN DEMAND (mg/kg)							
Oxygen demand, chemical, total	6	120,000	120,000	9,400	23,000	150,000	91,000
PHYSICAL PROPERTIES (mg/kg)							
Residue, loss on ignition	6	73,200	75,000	8,570	21,000	98,300	41,200

Table 31. Statistical summary of street-surface particulate quality samples: Commercial catchment—Continued

Constituent, in bottom materials	Number of samples	Mean	Median	Standard error of mean	Standard deviation	Maximum	Minimum
ORGANICS							
Carbon, inorganic plus organic, total (g/kg as C)	6	44	46	4	11	55	29
Carbon, inorganic, total (g/kg as C)	6	0.4	0.3	0.1	0.3	0.8	<0.1
Pesticides (total recoverable, µg/kg)							
Aldrin	3	1.8	<1.0	1.1	1.9	<4.0	<0.5
Chlordane	3	1,400	420	1,000	1,800	3,400	280
DDD	3	4.3	<4.0	2.0	3.5	7.9	<1.0
DDE	3	1.8	<1.0	1.1	1.9	<4.0	<0.5
DDT	3	7.8	3.3	5.7	9.8	19	<1.0
Diazinon	3	41	26	20	34	80	16
Dieldrin	3	32	6.8	28	49	89	1.2
Endosulfan	3	1.8	<1.0	1.1	1.9	<4.0	<0.5
Endrin	3	1.8	<1.0	1.1	1.9	<4.0	<0.5
Ethion	3	0.7	<1.0	0.3	0.5	<1.0	<0.1
Heptachlor epoxide	3	16	9.9	9.9	17	35	2.4
Heptachlor	3	2.0	2.2	0.7	1.2	3.0	0.7
Lindane	3	3.5	4.1	0.9	1.3	4.8	1.7
Malathion	3	12	15	3.9	6.8	17	4.4
Methoxychlor	3	3.2	<1.0	2.4	4.2	<8.0	<0.5
Methyl parathion	3	0.7	<1.0	0.3	0.5	<1.0	<0.1
Methyl trithion	3	0.7	<1.0	0.3	0.5	<1.0	<0.1
Mirex	3	1.8	<1.0	1.1	1.9	<4.0	<0.5
Parathion	3	13	<1.0	12	22	38	<0.1
Gross polychlorinated biphenyls	3	630	820	210	360	860	220
Gross polychlorinated naphthalenes	0	.	.	.	.	.	.
Perthane	3	18	<10	11	19	<40	<5
Toxaphene	3	180	<100	110	190	<400	<50
Trithion	3	0.7	<1.0	0.3	0.5	<1.0	<0.1
2,4-D	2	0.5	<0.5	0.0	0.0	<0.5	<0.5

Table 32. Percentage of runoff load attributable to rainfall load for the industrial and two residential catchments

[Rainfall total, in inches. Numbered columns below constituent names indicate (1) Rainfall drainoff load, in pounds; (2) Total runoff load, in pounds; (3) value of rainfall load to runoff load, in percent. ., no data available]

a. Industrial catchment

Storm beginning date	Storm ending date	Rainfall total	Nitrogen, ammonia plus organic, dissolved			Nitrogen, nitrite plus nitrate, dissolved			Phosphorus, dissolved		
			(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
12-29-81	12-29-81	0.18	1.4	29	4.8	0.24	1.7	14	0.12	11	1.1
01-04-82	01-04-82	0.62	6.3	165	3.8	0.96	13	7.4	0.53	56	1.0
03-19-82	03-10-82	0.33	.	38	.	0.81	1.2	70	0.40	15	2.6
03-10-82	03-11-82	0.20	4.8	.	.	0.94	.	.	0.39	.	.
03-25-82	03-26-82	0.24	3.5	30	12	0.89	2.4	38	0.27	11	2.5
09-24-82	09-24-82	0.20	1.0	7.6	13	0.30	1.1	28	0.89	1.3	6.9
10-25-82	10-25-82	0.19	.	2.2	.	.	0.24	.	.	0.49	.
10-26-82	10-26-82	0.59	7.4	.	.	0.87	.	.	0.40	.	.
11-09-82	11-09-82	0.45	3.7	43	8.6	0.28	1.1	25	0.03	9.9	0.3
01-18-82	01-19-82	0.78	19	98	19	1.6	9.7	17	0.48	40	1.2
01-23-83	01-24-83	0.70	10	.	.	0.90	.	.	0.09	.	.
Median percentage					10			25			1.2

Storm beginning date	Storm ending date	Oxygen demand, chemical, 0.25 N dichromate			Carbon, organic, dissolved (as C)			Iron, total recoverable		
		(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
12-28-81	12-29-81	27	952	2.9	4.7	128	3.6	.	14	.
01-04-82	01-04-82	128	6,710	1.9	55	962	5.8	.	158	.
03-09-82	03-10-82	42	930	4.5	7.3	480	1.5	.	9.5	.
03-10-82	03-11-82	67	.	.	19	.	.	.	.	.
03-25-82	03-26-82	54	709	7.6	8.3	409	2.0	.	8.3	.
09-24-82	09-24-82	.	.	.	.	.	.	0.88	3.7	24
10-25-82	10-25-82	.	.	.	.	.	.	0.11	1.2	9.2
10-26-82	10-26-82	181	.	.	30	.	.	0.27	.	.
11-09-82	11-09-82	28	1,670	1.7	7.7	170	4.5	0.99	26	3.8
01-18-83	01-19-83	162	.	.	44	.	.	0.97	183	0.5
01-23-83	01-24-83	90	.	.	36	.	.	0.09	.	.
Median percentage				2.9			3.6			6.5

Storm beginning date	Storm ending date	Lead, total recoverable			Nickel, total recoverable			Zinc, total recoverable		
		(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
12-29-81	12-29-81	.	0.15	.	.	0.04	.	.	0.88	.
01-04-82	01-04-82	0.08	1.2	6.7	.	0.32	.	.	6.1	.
03-09-82	03-10-82	0.02	0.11	18	.	0.01	.	.	0.94	.
03-10-82	03-11-82	0.02	.	.	.	.	.	.	.	.
03-25-82	03-26-82	0.03	0.10	30	.	0.05	.	.	0.98	.
09-24-82	09-24-82	0.02	0.02	100	<0.01	0.01	.	.	.	.
10-25-82	10-25-82	<0.01	0.01	.	<0.01	<0.01	.	0.01	.	.
10-26-82	10-26-82	0.03	.	.	0.03	.	.	.	.	.
11-09-82	11-09-82	0.02	0.24	8.3	0.03	0.05	60	0.20	1.6	12
01-18-83	01-19-83	0.03	1.3	2.3	0.02	0.41	4.9	0.65	.	.
01-23-83	01-24-83	0.02	.	.	0.01	.	.	.	.	.
Median percentage				13			32			.

Table 32. Percentage of runoff load attributable to rainfall load for the industrial and two residential catchments—Continued

b. Single-dwelling residential catchment

Storm beginning date	Storm ending date	Rainfall total	Nitrogen, ammonia plus organic, dissolved			Nitrogen, nitrite plus nitrate, dissolved			Phosphorus, dissolved		
			(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
03-25-82	03-26-82	0.20	0.85	1.5	57	0.29	0.42	69	0.03	0.18	17
03-28-82	03-29-82	0.45	1.8	.	.	0.33	.	.	0.02	.	.
03-31-82	03-31-82	0.95	1.8	3.4	53	0.20	0.87	23	0.05	0.53	9.4
09-24-82	09-24-82	0.22	.	6.9	.	0.36	1.9	19	0.08	0.59	14
10-25-82	10-25-82	0.09	.	1.3	.	.	0.26	.	.	0.08	.
10-26-82	10-26-82	0.69	3.7	8.2	45	0.37	1.2	31	0.04	0.72	5.6
01-18-83	01-19-83	0.85	2.5	6.3	40	0.36	0.86	42	0.07	0.72	9.7
01-24-83	01-24-83	0.74	1.5	8.5	18	0.50	2.0	25	0.05	0.70	7.1
02-28-83	03-01-83	1.11	3.2	4.5	72	0.64	0.90	71	0.06	0.58	10
03-16-83	03-16-83	0.40	1.1	2.3	48	0.75	0.82	91	0.05	0.25	20
03-23-83	03-23-83	0.57	1.7	4.3	40	0.28	0.43	65	0.03	0.43	7.0
Median percentage -------------------------					46			42			9.7

Storm beginning date	Storm ending date	Oxygen demand, chemical, 0.25 N dichromate			Carbon, organic, dissolved (as C)			Iron, total recoverable		
		(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
03-25-82	03-26-82	20	85	23	4.0	66	6.1	.	0.30	.
03-28-82	03-29-82	22	.	.	6.8	.	.	.	.	.
03-31-82	03-31-82	60	366	16	.	747	.	.	4.5	.
09-24-82	09-24-82	.	.	.	.	.	.	0.46	6.0	7.7
10-25-82	10-25-82	.	.	.	.	.	.	0.30	1.6	19
10-26-82	10-26-82	37	.	.	8.5	.	.	0.33	18	1.8
01-18-83	01-19-83	62	.	.	.	.	.	0.33	4.4	7.5
01-24-83	01-24-83	50	235	21	10	101	10	0.20	11	1.8
02-28-83	03-01-83	64	173	37	15	28	54	0.06	30	0.2
03-16-83	03-16-83	33	79	42	5.4	74	7.3	0.28	1.3	22
03-23-83	03-23-83	49	120	40	11	77	14	0.17	2.7	6.3
Median percentage -------------------				30			10			6.9

Storm beginning date	Storm ending date	Lead, total recoverable			Nickel, total recoverable			Zinc, total recoverable		
		(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
03-25-82	03-26-82	0.02	0.05	40	.	0.01	.	.	0.06	.
03-28-82	03-29-82	0.02	.	.	.	.	.	.	.	.
03-31-82	03-31-82	0.02	0.43	4.6	.	0.01	.	.	0.29	.
09-24-82	09-24-82	0.01	0.44	2.3	<0.01	0.03	.	.	.	.
10-25-82	10-25-82	0.01	0.12	8.3	<0.01	0.01	.	.	.	.
10-26-82	10-26-82	0.02	1.3	1.5	0.03	0.07	43	.	.	.
01-18-83	01-19-83	0.02	0.40	5.0	<0.01	0.02	.	0.22	.	.
01-24-83	01-24-83	0.02	0.50	4.0	0.05	0.08	62	.	0.40	.
02-28-83	03-01-83	0.01	0.62	1.6	0.03	0.07	43	0.19	0.77	25
03-16-83	03-16-83	0.02	0.11	18	0.02	0.02	100	.	0.10	.
03-23-83	03-23-83	0.02	0.17	12	0.01	0.02	50	.	0.17	.
Median percentage--------------------				4.3			50			.

Table 32. Percentage of runoff load attributable to rainfall load for the industrial and two residential catchments—Continued

c. Multiple-dwelling residential catchment

Storm beginning date	Storm ending date	Rainfall total	Nitrogen, ammonia plus organic, dissolved			Nitrogen, nitrite plus nitrate, dissolved			Phosphorus, dissolved		
			(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
12-29-81	12-30-81	0.38	0.56	1.1	51	0.12	0.34	35	0.02	0.19	11
01-04-82	01-04-82	0.83	1.6	2.7	59	0.27	0.59	46	0.03	0.64	4.7
09-24-82	09-24-82	0.22	.	5.1	.	0.41	1.5	27	0.10	0.53	19
10-26-82	10-26-82	0.69	5.4	24	22	0.54	1.2	45	0.05	1.1	4.5
11-09-82	11-09-82	0.45	1.6	2.5	64	0.21	0.64	33	0.02	0.36	5.6
01-18-83	01-19-83	0.85	3.0	7.1	43	0.43	1.3	33	0.09	1.6	5.6
01-24-83	01-24-83	0.74	1.7	5.6	30	0.57	1.1	52	0.06	0.50	12
03-16-83	03-16-83	0.40	1.6	2.0	78	1.0	1.8	56	0.07	0.33	21
03-23-83	03-23-83	0.57	3.1	4.7	66	0.52	0.84	62	0.05	0.42	12
Median percentage					55			45			11

Storm beginning date	Storm ending date	Oxygen demand, chemical, 0.25 N dichromate			Carbon, organic, dissolved (as C)			Iron, total recoverable		
		(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
12-29-81	12-30-81	13	83	16	2.6	8.1	32	.	7.7	.
01-04-82	01-04-82	36	163	22	6.3	27	23	.	24	.
09-24-82	09-24-82	.	.	.	.	.	.	0.53	21	2.5
10-26-82	10-26-82	54	.	.	12	.	.	0.48	148	0.3
11-09-82	11-09-82	23	137	17	8.7	20	44	0.64	6.4	10
01-18-83	01-19-83	73	.	.	.	.	.	0.39	26	1.5
01-24-83	01-24-83	57	350	16	12	63	19	0.23	38	0.6
03-16-83	03-16-83	44	245	18	7.3	73	10	0.38	9.1	4.2
03-23-83	03-23-83	89	200	45	21	126	17	0.32	13	2.5
Median percentage				17			21			2.5

Storm beginning date	Storm ending date	Lead, total recoverable			Nickel, total recoverable			Zinc, total recoverable		
		(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
12-29-81	12-30-81	.	0.20	.	.	0.02	.	.	0.18	.
01-04-82	01-04-82	0.01	0.66	1.5	.	0.05	.	.	0.58	.
09-24-82	09-24-82	0.01	0.35	2.9	<0.01	0.08	.	.	.	.
10-26-82	10-26-82	0.02	1.5	1.3	0.05	0.45	11	.	.	.
11-09-82	11-09-82	0.01	0.21	4.8	0.01	0.02	50	0.11	0.23	48
01-18-83	01-19-83	0.02	0.83	2.4	<0.01	0.10	.	0.26	.	.
01-24-83	01-24-83	0.02	0.81	2.5	0.06	0.12	50	.	0.75	.
03-16-83	03-16-83	0.03	0.18	17	0.02	0.05	40	.	0.31	.
03-23-83	03-23-83	0.04	0.33	12	0.02	0.05	40	.	0.37	.
Median percentage				3.8			40			.

Table 33. Summary of pesticides detected in rainfall, runoff, atmospheric dry-deposition, and street-surface particulate samples

[ND, not detected; D, detected; ., no data available]

Pesticide (total recoverable)	Rainfall		Runoff		Atmospheric dry deposition		Street-surface particulate	
	Number of samples	Detection status	Number of samples	Detection status	Number of samples	Detection status	Number of samples	Detection status
Gross measures								
Polychlorinated biphenyls	50	ND	86	D	2	ND	18	D
Polychlorinated napthalenes	50	ND	86	ND	2	ND	6	ND
Organochlorine compounds								
Aldrin	50	ND	86	D*	2	ND	18	ND
Chlordane	50	D	84	D	2	D	18	D
DDD	50	ND	86	ND	2	ND	18	D*
DDE	50	D	86	D	2	D	18	D
DDT	50	ND	86	D	2	ND	18	D
Dieldrin	50	D	86	D	2	ND	18	D*
Endosulfan	50	D	86	D	2	ND	18	D*
Endrin	50	ND	86	D*	2	ND	18	ND
Heptachlor	50	ND	86	ND	2	ND	18	D
Heptachlor epoxide	50	ND	86	ND	2	ND	18	D
Lindane	50	D	86	D	2	D	18	D
Methoxychlor	50	D	86	D	2	D	18	ND
Mirex	50	ND	86	ND	2	ND	18	ND
Perthane	50	ND	86	ND	2	ND	18	ND
Toxaphene	50	ND	86	ND	2	ND	18	ND
Organophosphorus compounds								
Diazinon	54	D	85	D	2	D	18	D
Ethion	54	D*	86	ND	2	ND	18	ND
Malathion	54	D	85	D	2	D	18	D
Methyl parathion	54	D*	85	D*	2	ND	18	ND
Methyl trithion	54	ND	86	ND	2	ND	18	ND
Parathion	54	D	85	D	2	ND	18	D
Trithion	54	ND	86	ND	2	ND	18	ND
Carbamate insecticides								
Methomyl	10	ND	27	ND	.	.	.	.
Propham	10	ND	27	ND	.	.	.	.
Sevin	10	ND	27	ND	.	.	.	.
Chlorophenoxy acid herbicides								
2,4-D	44	D	84	D	2	ND	8	ND
2,4-DP	44	ND	84	ND	2	ND	.	.
2,4,5-T	44	ND	84	ND	2	ND	.	.
Silvex	44	ND	84	D	2	ND	.	.

*Detected for only one sample.

Table 34. Statistical summary of pesticides detected in rainfall samples

[Mean and standard deviation determined if all values were greater than or equal to the detection limit. Pesticide values are shown in micrograms per liter. <, actual value is less than value shown. ., not calculated]

Pesticide (total recoverable)	Number of samples	Number of samples that equaled or exceeded the detection limit	Mean	Median	Standard deviation	Minimum	Maximum
Organophosphorus compounds							
Diazinon	54	54	0.14	0.11	0.15	0.01	0.93
Malathion	54	50	.	0.02	.	<0.01	0.11
Parathion	54	49	.	0.16	.	<0.01	1.00
Organochlorine compounds							
DDE	50	8	.	<0.01	.	<0.01	0.02
Dieldrin	50	37	.	<0.01	.	<0.01	0.04
Chlordane	50	8	.	<0.10	.	<0.10	0.40
Endosulfan	50	14	.	<0.01	.	<0.01	0.10
Lindane	50	37	.	0.01	.	<0.01	0.04
Methoxychlor	50	7	.	<0.01	.	<0.01	0.12
Chlorophenoxy acid herbicide							
2,4-D	44	10	.	<0.01	.	<0.01	0.08

Table 35. Statistical summary of most frequently detected pesticides in runoff for each catchment

[Mean and standard deviation determined if all values were greater than or equal to the detection limit. Pesticide values are shown in micrograms per liter. ,<actual value is less than value shown. ., not calculated]

Pesticide (total recoverable)	Number of samples	Number of samples that equaled or exceeded the detection limit	Mean	Standard deviation	Minimum	Maximum
		Industrial catchment				
Organophosphorus compounds						
Parathion	18	5	.	.	<0.01	0.38
Diazinon	18	18	0.67	0.71	0.20	3.3
Malathion	18	18	0.66	0.67	0.20	3.0
Organochlorine compounds						
Chlordane	19	5	.	.	<0.10	0.30
Lindane	19	19	0.05	0.06	0.01	0.27
Chlorophenoxy acid herbicide						
2,4-D	19	14	.	.	<0.01	3.2
		Single-dwelling residential catchment				
Organophosphorus compounds						
Parathion	16	13	.	.	<0.01	0.92
Diazinon	16	16	0.36	0.27	0.11	1.1
Malathion	16	16	2.2	3.3	0.19	13
Organochlorine compounds						
Chlordane	16	16	0.16	0.07	0.10	0.30
Lindane	16	16	0.03	0.02	0.01	0.06
Chlorophenoxy acid herbicide						
2,4-D	16	14	.	.	<0.01	1.7
		Multiple-dwelling residential catchment				
Organophosphorus compounds						
Parathion	27	16	.	.	<0.01	2.5
Diazinon	27	27	0.68	1.5	0.06	8.1
Malathion	27	27	1.3	2.6	0.08	14
Organochlorine compounds						
Chlordane	26	21	.	.	<0.10	1.2
Lindane	27	22	.	.	<0.01	0.03
Chlorophenoxy acid herbicide						
2,4-D	26	21	.	.	<0.01	3.7
		Commercial catchment				
Organophosphorus compounds						
Parathion	24	17	.	.	<0.01	0.90
Diazinon	24	24	1.6	3.7	0.13	18
Malathion	24	24	0.28	0.25	0.08	1.4
Organochlorine compounds						
Chlordane	23	15	.	.	<0.10	0.30
Lindane	24	23	.	.	<0.01	0.03
Chlorophenoxy acid herbicide						
2,4-D	23	13	.	.	<0.01	0.63

GPO 685-041/9802

SELECTED SERIES OF U.S. GEOLOGICAL SURVEY PUBLICATIONS

Periodicals

Earthquakes & Volcanoes (issued bimonthly).
Preliminary Determination of Epicenters (issued monthly).

Technical Books and Reports

Professional Papers are mainly comprehensive scientific reports of wide and lasting interest and importance to professional scientists and engineers. Included are reports on the results of resource studies and of topographic, hydrologic, and geologic investigations. They also include collections of related papers addressing different aspects of a single scientific topic.

Bulletins contain significant data and interpretations that are of lasting scientific interest but are generally more limited in scope or geographic coverage than Professional Papers. They include the results of resource studies and of geologic and topographic investigations; as well as collections of short papers related to a specific topic.

Water-Supply Papers are comprehensive reports that present significant interpretive results of hydrologic investigations of wide interest to professional geologists, hydrologists, and engineers. The series covers investigations in all phases of hydrology, including hydrogeology, availability of water, quality of water, and use of water.

Circulars present administrative information or important scientific information of wide popular interest in a format designed for distribution at no cost to the public. Information is usually of short-term interest.

Water-Resources Investigations Reports are papers of an interpretive nature made available to the public outside the formal USGS publications series. Copies are reproduced on request unlike formal USGS publications, and they are also available for public inspection at depositories indicated in USGS catalogs.

Open-File Reports include unpublished manuscript reports, maps, and other material that are made available for public consultation at depositories. They are a nonpermanent form of publication that may be cited in other publications as sources of information.

Maps

Geologic Quadrangle Maps are multicolor geologic maps on topographic bases in 7 1/2- or 15-minute quadrangle formats (scales mainly 1:24,000 or 1:62,500) showing bedrock, surficial, or engineering geology. Maps generally include brief texts; some maps include structure and columnar sections only.

Geophysical Investigations Maps are on topographic or planimetric bases at various scales; they show results of surveys using geophysical techniques, such as gravity, magnetic, seismic, or radioactivity, which reflect subsurface structures that are of economic or geologic significance. Many maps include correlations with the geology.

Miscellaneous Investigations Series Maps are on planimetric or topographic bases of regular and irregular areas at various scales; they present a wide variety of format and subject matter. The series also includes 7 1/2-minute quadrangle photogeologic maps on planimetric bases which show geology as interpreted from aerial photographs. Series also includes maps of Mars and the Moon.

Coal Investigations Maps are geologic maps on topographic or planimetric bases at various scales showing bedrock or surficial geology, stratigraphy, and structural relations in certain coal-resource areas.

Oil and Gas Investigations Charts show stratigraphic information for certain oil and gas fields and other areas having petroleum potential.

Miscellaneous Field Studies Maps are multicolor or black-and-white maps on topographic or planimetric bases on quadrangle or irregular areas at various scales. Pre-1971 maps show bedrock geology in relation to specific mining or mineral-deposit problems; post-1971 maps are primarily black-and-white maps on various subjects such as environmental studies or wilderness mineral investigations.

Hydrologic Investigations Atlases are multicolored or black-and-white maps on topographic or planimetric bases presenting a wide range of geohydrologic data of both regular and irregular areas; principal scale is 1:24,000 and regional studies are at 1:250,000 scale or smaller.

Catalogs

Permanent catalogs, as well as some others, giving comprehensive listings of U.S. Geological Survey publications are available under the conditions indicated below from the U.S. Geological Survey, Books and Open-File Reports Section, Federal Center, Box 25425, Denver, CO 80225. (See latest Price and Availability List.)

"Publications of the Geological Survey, 1879- 1961" may be purchased by mail and over the counter in paperback book form and as a set of microfiche.

"Publications of the Geological Survey, 1962- 1970" may be purchased by mail and over the counter in paperback book form and as a set of microfiche.

"Publications of the U.S. Geological Survey, 1971- 1981" may be purchased by mail and over the counter in paperback book form (two volumes, publications listing and index) and as a set of microfiche.

Supplements for 1982, 1983, 1984, 1985, 1986, and for subsequent years since the last permanent catalog may be purchased by mail and over the counter in paperback book form.

State catalogs, "List of U.S. Geological Survey Geologic and Water-Supply Reports and Maps For (State)," may be purchased by mail and over the counter in paperback booklet form only.

"Price and Availability List of U.S. Geological Survey Publications," issued annually, is available free of charge in paperback booklet form only.

Selected copies of a monthly catalog "New Publications of the U.S. Geological Survey" available free of charge by mail or may be obtained over the counter in paperback booklet form only. Those wishing a free subscription to the monthly catalog "New Publications of the U.S. Geological Survey" should write to the U.S. Geological Survey, 582 National Center, Reston, VA 22092.

Note.--Prices of Government publications listed in older catalogs, announcements, and publications may be incorrect. Therefore, the prices charged may differ from the prices in catalogs, announcements, and publications.